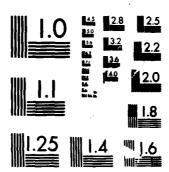
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US Army Corps of Engineers New Orleans District CULTURAL RESOURCES SERIES

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EVALUATION OF THE NATIONAL REGISTER ELIGIBILITY OF THE INNER HARBOR NAVIGATION CANAL LOCK IN ORLEANS PARISH, LOUISIANA.

Report Number:

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June 15, 1987

FINAL REPORT

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Prepared for

U.S. Army Corps of Engineers

New Orleans District

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outlined. Following this discussion, the IHNC lock is described briefly.

Chapter II of this report addresses the natural setting of the project area. Local geomorphology, Mississippi River Delta soil conditions, and the area between Lake Pontchartrain and the Mississippi River are discussed. Chapter III presents the historic setting of the area which is now the Inner Harbor Navigation Canal (IHNC). In this section, land use patterns are discussed, as are important events and prior local navigation projects,

Chapter IV develops an historical overview of inland navigation in the United States, This chapter reviews the development of Federal policies preceding and during the period of construction of the nation's inland waterways and places the IHNC within a national historic context. Chapter V contains a detailed account of the events surrounding the design and construction of the Industrial Canal (IHNC) and lock. Close attention is paid to the issues of locating and funding the canal, as well as to the difficulties encountered during excavation and construction.

Chapter VI traces the development of technologies associated with the design and construction of navigational locks. Various historic solutions are presented in chronological order. This section places the methods of construction and the mechanical systems used at the IHNC lock in their context within the history of engineering. Chapter VII then describes several nationally significant lock complexes built during the same period as the IHNC; navigational locks in the New Orleans area also are discussed. This chapter, then, provides a comparative base for critical analysis of the IHNC lock,

Chapter VIII continues with a detailed description of the IHNC lock. All salient features of the lock are described, so that their significance within the established historic themes is understood. Plans and photographs are provided for additional clarity. This section ends with a brief assessment of the importance of the IHNC project within the field of engineering.

Chapter IX reviews the effects of the construction of the IHNC on the Port of New Orleans; Shipping statistics and annual economic figures are presented and interpreted. The result is assessment of the economic and commercial ramifications of the IHNC on New Orleans' economy.

Chapter X assesses the current level of historical integrity at the IHNC lock dewaterings and routine maintenance activities are reviewed. In addition, serious navigation accidents which caused damage to the lock are described in detail. And, modifications to the original 1918 design are discussed.

Chapter XI presents the conclusions and recommendations. The historic themes specific to this National Register assessment are briefly restated. The applicable National Register criteria are applied, and the significance of the IHNC lock is substantiated. Finally, mitigation alternatives are discussed.

IFRIY TO ATTENTION OF

DEPARTMENT OF THE ARMY

NEW ORLEANS DISTRICT, CORPS OF ENGINEERS

P.O. BOX 60267

NEW ORLEANS, LOUISIANA 70160-0267

Planning Division Environmental Analysis Branch

To the Reader:

This report was prepared for the U.S. Army Corps of Engineers, New Orleans District, in order to evaluate the historic significance of the Inner Harbor Navigation Canal (IHNC) Lock. The subject was well researched and will serve as an excellent compilation of information about the IHNC Lock facility as well as the New Orleans economy in the early twentieth century. The Contractor is complimented for a job well done.

We concur with the Contractor's conclusion that the IHNC Lock is eligible for nomination to and inclusion on the National Register of Historic Places. The IHNC Lock meets both Criteria A and C for inclusion on the National Register. The lock has a significant association with events that have contributed to the broad patterns of American History (Criterion A). It is an outstanding example of a navigation lock, and it embodies the distinctive characteristics of its type and period of construction (Criterion C). The IHNC Lock is significant at the local, state, and national levels. In addition, it shows integrity of design, association, feeling, setting, materials, workmanship, and location.

Technical Repřesentative

lawlin H. alleight

Caroline H. Albright

Authorized Representative of the Contracting Officer

Cletis R. Wagenoff

Chief, Planzing Division

ACKNOWLEDGEMENTS

We would like to express our thanks to those people who have contributed invaluable information and assistance to this report. We would like to thank Dr. Ed Lyon, who served as the Technical Representative for the project. Dr. Lyon not only was able to provide our office with Corps of Engineers documents necessary to the assessment of the IHNC lock, but he also helped to formulate, direct, and encourage this research. In addition, Ms. Caroline Albright served as the Contracting Officer's Representative, and she was involved actively in the review of the research strategies undertaken. Other New Orleans District, Corps of Engineers personnel who provided assistance included Captain David Cobb, lockmaster at IHNC; Mr. Keith Alexander, lockmaster at Harvey; and Mr. John Whalen, head-mechanic at the Algiers lock. Mr. Charles Everhardt and Ms. Dawn Aymami of the Locks and Dams Division of the Corps of Engineers provided much of the necessary background information on maintenance of and modifications to the IHNC lock.

We also would like to thank Mrs. Louise Gashy of the Records Office, Board of Commissioners of the Port of New Orleans. Mrs. Gashy's experience with the filing system at the records office enabled us to obtain the exact documents we needed for compilation of data on lock maintenance, modifications, and navigational accidents. Mr. James Cripps, AIA, provided assistance in the assessment of integrity of the IHNC lock. Finally, we wish to thank Sister Joan Marie, O.S.U., of the Ursuline Convent, New Orleans. Sister Joan Marie was of great assistance during research into the historic configuration of the land now occupied by the Industrial Canal.

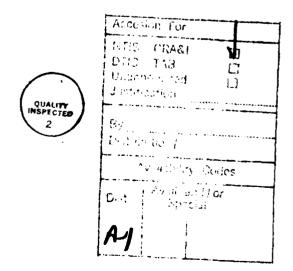


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CHAPTER I

INTRODUCTION

This report, undertaken for the New Orleans District, Corps of Engineers, pursuant to Contract No. DACW29-86-D-0093, presents the results of an evaluation of the Inner Harbor Navigation Canal lock (IHNC) facility in New Orleans, Louisiana. The purpose of this report is the assessment of the historical significance, and thus of the potential eligibility of the IHNC lock for nomination to or inclusion on the National Register of Historic Places.

This evaluation examines the existing lock complex in terms of the National Register criteria (36 CFR 60.4), and it applies the seven criteria for determining integrity (location, design, setting, materials, workmanship, association, and feeling). Inner Harbor Navigation Canal lock complex also is evaluated in terms of its national, state, and local significance by examining the relationship of the lock complex to important historical themes, e.g., the history of navigation, National Defense, and engineering history. Finally, the association and involvement of Major General George Washington Goethals, the "architect" of the Panama Canal, with the construction of the locks was assessed and evaluated in order to determine his role in the design and construction of the lock facility. These assessments, and the conclusions and recommendations derived from them, are based on extensive archival research, on comparative analyses of the IHNC facility with other locks, on oral interviews, and on physical examination of the existing lock complex.

The Inner Harbor Navigation Canal Complex

The Inner Harbor Navigation Canal lock complex (Figure 1) is located at the intersection of Urquhart Street and the Inner Harbor (also Navigation Canal called the Industrial Canal). Construction of the lock complex was begun in 1918 and completed in 1923, when the canal was connected to the river and the lock complex first was opened to water traffic. The lock is designed to allow ships to pass through the canal by equalizing water levels between Lake Pontchartrain and the Mississippi River. Normally, the Mississippi River is higher than the lake, although this is not always the case. The construction of the lock was essential to connecting the Mississippi River to Lake Pontchartrain; before the construction of the lock, the difference in elevation of water levels between the lake and the river precluded water travel back and forth. In addition, the lock serves as a flood prevention device that can be used to resist storm surges from the river or from the lake. Such surges are associated with hurricanes

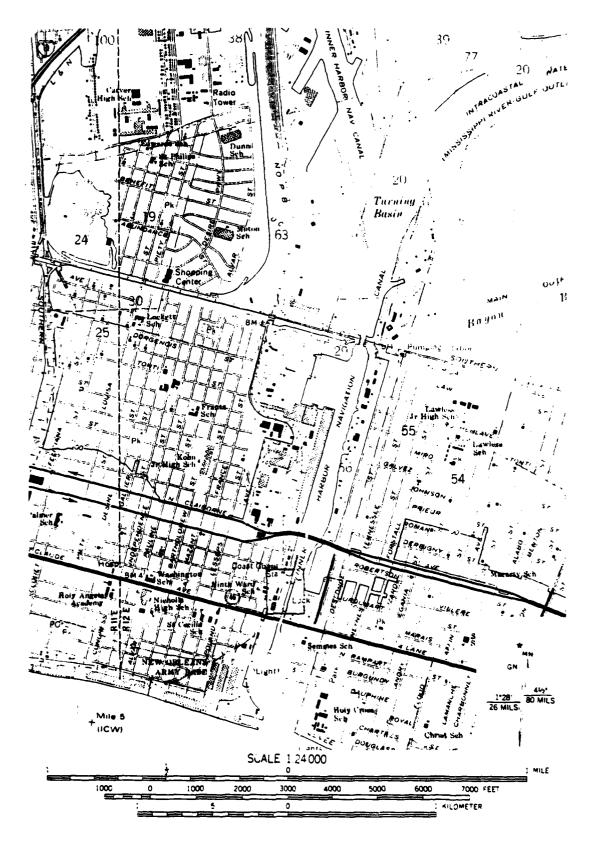


Figure 1. Location of IHNC lock; portion of USGS 7.5' quadrangle, New Orleans East, LA.

traveling north from the Gulf of Mexico.

The construction of the lock and of the Industrial Canal was the result of an extensive and dangerous project (workers were plagued by marsh gases, quicksand, and insects) funded through bond issue by the citizens of New Orleans. The catalyst for the project was the decline in shipping which occurred in New Orleans during the late nineteenth and early twentieth centuries. The completion of the Industrial Canal and Lock facility shortened the navigable distance between New Orleans and the Gulf of Mexico, and thus stimulated shipping in the region by making New Orleans a more viable port.

The Inner Harbor Navigation Canal lock consists of a reinforced concrete lock chamber with a usable length of 675 feet; the usable width is 75 feet (Figure 2). The machinery used to open and close the massive gates at the locks is very similar in design to those at the Panama Canal. In addition, the complex contains an emergency dam which is utilized when the lock is dewatered; it also serves as a defense mechanism against storm surges. The IHNC lock facility has been in continuous operation (with the exception of occasional dewaterings for maintenance purposes) since it was completed in 1923. Several of the components designed and constructed at the IHNC lock were the first of their kind; these components will be discussed in subsequent sections of this report, and they will be compared to contemporary lock complexes in the United States, Canada, and Europe.

The present lock complex, although fully operational, has inadequate length and width for modern deep draft vessels and for large tows; a new lock complex is necessary to assure that New Orleans remains a viable port with good access to the Gulf of Mexico. The New Orleans District, Corps of Engineers, has proposed two alternatives to address this problem. The first alternative is to construct a new facility at the present site of the existing lock complex. This alternative would involve the demolition of the IHNC lock complex, and the construction of a new facility designed to increase the speed and volume of lockages. The second alternative is to build a new lock complex at a location downriver from the present site, in Violet, Louisiana. As stated above, this report is designed to evaluate the existing lock structure using the National Register criteria (36 CFR 60.4), to determine the eligibility of the complex for the National Register of Historic Places, and to present mitigation alternatives if the lock structure is determined to be eligible for nomination to and inclusion on the National Register. The critical evaluation of the inadequacies of the lock in terms of present shipping needs was not the objective of this report (see Appendix I, Scope of Services).

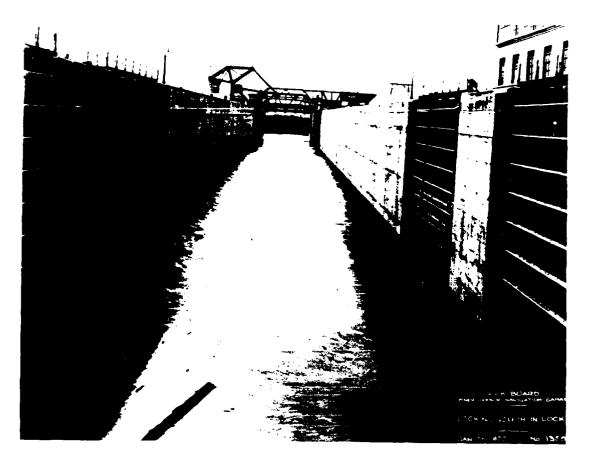


Figure 2. IHNC lock chamber (looking South toward the Mississippi River) (photograph courtesy of the Port of New Orleans).

Sources Used During Research

The archival sources utilized during the research for the project include: Annual Reports to the Chief of Engineers, records of the Board of Commissioners, Port of New Orleans; newspapers, the Readers Guide to Periodical Literature, appropriate scholarly journals, and previous investigations into the history of navigation and navigation-related structures. In addition, a computerized bibliographic search of relevant holdings of the Library of Congress was conducted. Research facilities included U.S. Army Corps of Engineers, New Orleans District Library, the Historic New Orleans Collection, Ursuline Convent, and the Tulane, Loyola, and University of New Orleans Libraries. Oral histories specific to the IHNC lock complex also were compiled; the most informative portions of these are included in the text of this sectional drawings report. In addition, plans and contemporary lock complexes were obtained from the National Cartographic and Topographical Archives in Washington, D.C. These drawings were necessary for accurate comparative analysis.

Organization of the Report

This report begins with a description of the natural setting and geomorphological setting of the project area (i.e. the area of the Industrial Canal between Lake Pontchartrain and the Mississippi River). This discussion (Chapter II) clarifies the reasons why construction of the canal and locks was both dangerous and expensive. Next, the historical setting of the project area is discussed in order to elucidate settlement patterns and land tenure history in the project area. Chapter III reviews earlier local navigation projects, such as the Carondelet and Basin Street Canals. Chapter IV continues with an historical overview of the history of man-made inland waterway projects undertaken in the United States and Canada, with special reference to the significance of New Orleans' connection to the Gulf Intracoastal Waterway (GIWW). Chapter V sets the historical context of the IHNC project. This context also includes associated legislation and funding issues, as well as a description of the construction project itself.

The assessment of the significance of the IHNC locks as an engineering complex also requires understanding and interpretation of events that occurred in the fields of structural, hydraulic, and mechanical engineering during the late nineteenth and early twentieth centuries. Chapt r VI is devoted to advances in those fields during that period. Significant lock and dam facilities and mechanisms then are described in Chapter VII of this report; illustrations are provided to clarify

discussions. The contributions of General Goethals to the practice of engineering, as well as a description of the Panama Canal project, also are contained within Chapter VII. The net result is the development of the historical context of the IHNC construction project in terms of the engineering sciences.

Chapter VIII is a detailed description of the IHNC lock complex. This physical description of the structural methods and mechanical devices at the IHNC then are compared to those complexes reviewed in the previous chapter, so that significant features of the IHNC locks, and their impacts on the field of engineering, are clear.

Chapter IX traces the development of the Port of New Orleans and its relationship to the construction of the Inner Harbor Navigation Canal and the Gulf Intracoastal Waterway. As part of this analysis, shipping statistics and revenues from the port are reviewed. Additionally, industrial development along the Industrial Canal corridor is discussed, as is the significance of that development. The economic history of the IHNC lock is examined in terms of annual and long term variations in shipping.

Chapter X is devoted to the effects of the years of shipping activity on the IHNC lock complex, as well as changes in jurisdiction and ownership which have occurred. Essentially, this section is a critical evaluation of how the locks have performed over the years. Significant modifications to the complex are described, as are serious navigation accidents. In addition, the results of periodic dewaterings, and of routine maintenance procedures, are discussed briefly. Thus, this chapter examines the historical integrity of the IHNC lock complex by reviewing changes in design, materials, and workmanship.

Chapter XI presents conclusions and recommendations about the historicity and treatment of the IHNC lock. Significant historical themes discussed in the text are restated briefly, and then are applied in the context of the National Register criteria. The issues of integrity outlined in the previous chapter then are evaluated. The result is an assessment of eligibility of the IHNC lock complex for nomination to and inclusion on the National Register of Historic Places.

Finally, the planned U.S. Army Corps of Engineers, New Orleans District lock expansion project is described, and impacts to the lock, both direct and indirect, are assessed. Mitigation alternatives (Manual of Mitigation Measures), as well as proposals to reduce negative impacts, ar. presented.

Authors and Responsibilities

Dr. R. Christopher Goodwin served as Principal Investigator for this project, and he was responsible for overall project direction, organization, and quality control. Dr. Goodwin also supervised scheduling and report preparation. In addition, Dr. Goodwin worked closely with his project team in evaluation of all data pursuant to application of the National Register criteria, and assessment of the integrity of the IHNC lock complex.

Dr. Frederick Dobney and Dr. David Moore of Loyola University senior historians for this project. Their served responsibilities included the development of the historical context for the IHNC lock complex. Dr. Dobney and Dr. Moore researched the history of earlier navigation projects that had to connect the Mississippi River with Pontchartrain; they also researched the development of man-made inland waterways elsewhere in the United States. This study included the legislation which made these projects possible, as well as the specific goals, e.g., economics or national defense, they were designed to achieve. The result is a chronological overview of the historical development of such navigation projects that helps to establish the historical context of the construction of the IHNC lock complex. This historical context demonstrates the impact of the IHNC locks on local, state, and national navigation and economics.

Mr. Jeffrey Treffinger conducted a structural and mechanical evaluation of the lock complex. This study was designed to determine the present physical and operational states of the complex as compared to those of the original design intentions. In addition, Mr. Treffinger was responsible for placing the construction of the IHNC lock facility and related operating machinery within the context of the history of mechanical, structural, and hydraulic engineering. This was accomplished through research into other lock and dam facilities built during the late nineteenth and early twentieth centuries. A comparative analysis of methods and materials of construction associated with each of these significant complexes was undertaken. included extensive evaluation of the Panama Canal, which was completed in 1915 and which is regarded as the high water mark of hydraulic, structural, and mechanical engineering complexes of this period.

Dr. Mark Catlin conducted extensive archival research at the offices of the Board of Commissioners of the Port of New Orleans, in order to btain maintenance, accident, and shipping records. This research included examination of design modifications and dewatering procedures and repairs, as well as a compilation of routine maintenance operations. Dr. Catlin also was responsible

for the sections of this report examining the IHNC lock complex as a flood control device, and the economic growth of the Industrial Canal zone. Finally, Dr. Catlin worked closely with Dr. Dobney and with Dr. Moore on the section of this report tracing the development of man-made inland waterways in the United States.

Mr. Paul C. Armstrong was responsible for a search of periodical sources specific to the IHNC lock complex, and pertaining to contemporary lock facilities in the United States, Canada, and Europe. In addition, Mr. Armstrong prepared the section of this report on the historical setting of the project area. Mr. Armstrong also researched and wrote the section of this report describing the natural and geomorphological setting of the project area.

Mr. James Cripps was responsible for the interpretation of the maintenance records of the lock complex. His responsibilities included the development of an overview of maintenance activities, design modifications, and accidents which occurred at the lock complex since it opened in 1923. The purpose of this section was to identify the successes and deficiencies of the original design by reviewing modifications to the lock complex. The resultant chronological record was essential to determination of the present level of integrity existing at the IHNC lock complex.

Mr. David Poynter served as the illustrator for this report. Mr. Poynter worked closely with Mr. Treffinger in determining the figures which would best illustrate important structural or mechanical engineering issues, clarifying discussions in the text. Ms. Ana Maria Chandler produced the manuscript.

CHAPTER II

NATURAL SETTING

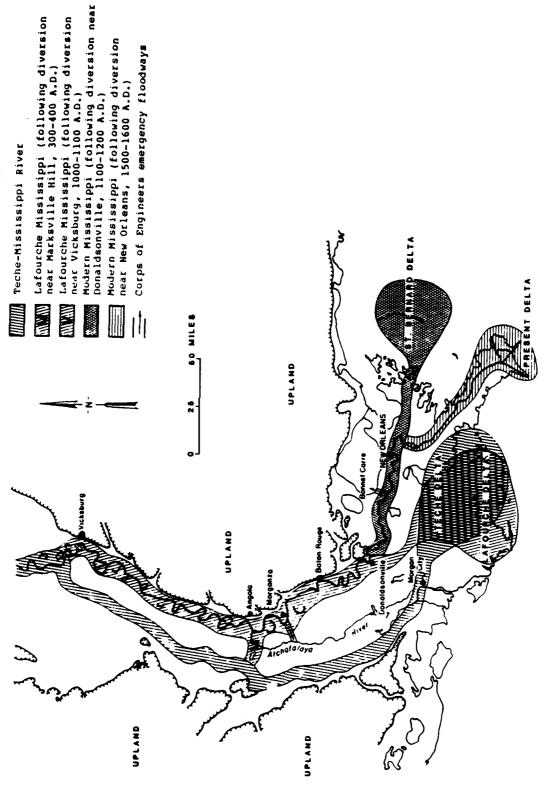
Introduction

The Inner Harbor Navigational Canal is located in the greater Mississippi Deltaic Plain. Within this deltaic plain, five major delta complexes have formed during the last 6,000 years (Frazier 1967). New Orleans is situated within the third subdelta, the St. Bernard Delta complex (Figure 3). This chapter addresses the geomorphic processes that formed the Mississippi Deltaic Plain, and describes the unique natural setting of the New Orleans area and of the St. Bernard Delta. In addition, this chapter reviews the natural and man-made processes that contributed to the low elevation of the area. Finally, a brief description is provided of the climatic conditions of the delta region. These descriptions present background information necessary to understanding some of the problems encountered during the construction of the IHNC through such a distinct landform.

The Mississippi Deltaic Plain

The Mississippi River delta is the largest active delta system in the North America. In fact, the Mississippi River is unique because of its delta. Most North American rivers lack deltas of any kind, and instead have mouths that are embayed, i.e., the sea has entered the river mouth and flooded it (Lewis 1976). The Mississippi River Deltaic Plain, which is the eighth largest deltaic plain in the world, is a classic river-dominated delta system (Wright et al. 1974). When compared with 34 other major delta systems around the world, the Mississippi River delta ranks first in its degree of riverine dominance over marine processes (Wright et al. 1974). The silts and clays deposited throughout the Mississippi delta over thousands of years include materials from mountains and valleys as far west as the Rockies (Larson et al. To a lesser degree, periodic glaciation and encroachment from the sea (via the Gulf of Mexico) also have contributed layers of organic and inorganic materials.

The recent geologic development of the Mississippi Deltaic Plain occurred during the period of rising sea level following the Pleistocene epoch. The sea level began to rise rapidly about 18,000 years ago, after a long period when the level of the world's oceans was almost 100 meters lower than it is today. While the sea level was low, a gigantic trough (the Mississippi Trench) was eroded offshore from the present Mississippi Deltaic Plain, across the Prairie Terrace Formation (the present Continental Shelf).



The ancient deltas of the Mississippi River including the St. Bernard delta lobe (after Fisk 1952). Figure 3.

As melting continental glaciers caused the sea level to rise, riverborne sediments from the Mississippi drainage began filling the trench, and the modern deltaic plain began to develop. The rate of increase in sea level gradually diminished until sometime between 3,000 to 5,000 B.P., when sea level stabilized at nearly its present level (Bahr et al. 1983)

According to Lewis (1976), continental glaciation prevented southern Louisiana from being totally submerged by the Gulf of Mexico for two reasons: first, the ice erased a number of preglacial drainage systems in the Midwest and rerouted drainage toward the Mississippi. As a result, the Mississippi River system was enlarged. Second, the ice carried an enormous volume of debris, while simultaneously generating windstorms which deposited blankets of silt all across the upper and lower Mississippi basin. As the ice melted, both iceborne debris and windblown silt eventually found their way into the river. The combination of an increased flow of water and an increased burden of material caused the Mississippi River to begin extending its delta at a rapid rate, filling the southern end of the embayment, even as it was sinking.

The St. Bernard Delta

As noted above, the Mississippi River Deltaic Plain is composed of at least five discernible subdeltas or delta complexes, each of which has several recognizable delta lobes or distributary networks (Frazier 1967). The Maringouin Delta Lobe developed between 6,200 to 7,200 years ago; the Teche Delta lobe originated approximately 3,900 to 5,700 years ago; the Lafourche Delta formed between 2,000 and 3,500 years ago; the St. Bernard Delta Lobe formed between 1,700 and 4,700 years ago; the Plaquemine Delta Lobe developed between 200 and 1,000 years ago; and, the Modern Delta Lobe began forming around two hundred years ago. (Saucier 1974).

The Mississippi River builds delta land in two ways, and both processes were active in the formation of the present New Orleans area. The first method of delta land formation is through the accumulation of Mississippi River deposits (alluvium) on route to the Gulf of Mexico. The second method of delta land formation involves a sudden and spectacular process. Every several hundred years (700 to 1,000 years, according to Bahr et al. 1983), the Mississippi abandons its path for a newer and more direct route to the sea (Kolb and Lopik 1958). This movement, known as river diversion, created huge gashes across the delta, resulting in massive land redistribution.

There is ample geologic evidence of numerous old Mississippi River channels and deltas active during the past 5,000 years within

the deltaic plain region (Figure 3). The oldest extinct course still visible is now occupied by Bayou Teche, in the Atchafalaya Basin. About halfway between the Teche and New Orleans is a more recent ancestor of the Mississippi, Bayou Lafourche. However, the best marked of the three previous deltas, and the one that is important to this project, is the St. Bernard Delta. Formative processes involved in the St. Bernard Delta lobe development are discussed below.

As the Mississippi River diverted to a new course and began to discharge into shallow bodies of water or to develop major crevasses into bays or lagoons, flow became restricted by natural levee growth to one or more of her distributaries. The natural levees formed subaqueous features ahead of the rapidly advancing distributary mouth, and gradually emerged as subaerial ridges (Saucier 1974).

Development of subaqueous bars at the distributary mouths, where the stream's load of silt and sand was deposited, caused frequent bifurcation or branching of the distributaries. Most branches remained active for only a short period of time before being abandoned. A single branch eventually became dominant and also built subaqueous bars. While the distributaries advanced seaward as long fingers of land, part of the river's suspended load of clay and silt was deposited ahead of and between the distributaries. This process of coastline advance formed the St. Bernard Delta complex.

The St. Bernard Delta is a triangular-shaped sedimentary complex that extends from New Orleans to the Chandeleur Islands. The delta was initiated when the Mississippi River diverted to an easterly course between 2600 B.P. and 2000 B.P. (Saucier 1974). The growth of the St. Bernard Delta was neither continuous nor uniform, since the Mississippi also was building deltas at Bayou Teche and Bayou Lafourche. In the early growth phase, deposition centered in the eastern New Orleans area. As the lobe extended gulfward, the channel enlarged, bifurcated, and reunited, forming an intricate network of distributary channels, levees, and interdistributary areas. Later, some distributaries were favored while others were abandoned. In the last phase of growth, deposition occurred primarily seaward of the distributary mouths in the vicinity of the Chandeleur Islands.

The growth of the St. Bernard Delta, which constitutes the western and southwestern boundaries of the Pontchartrain Basin, also contributed to the development of Lake Pontchartrain. Ancient sand barriers that were not covered by alluvial deposition along the western and eastern edges of the Pontchartrain Basin restricted salt water intrusion (Gagliano et al. 1978). With the river building land masses, and with the introduction of fresh

water from the west, Lake Pontchartrain began as a brackish embayment. As the St. Bernard Delta continued its eastward development, the bay eventually closed to become a brackish lake (Frazier and Osanik 1977).

The Geomorphic Setting

Landforms within the St. Bernard Delta complex were principally swamp, marsh, and natural levee. Soils and soil types that characterize or that normally are associated with these landforms vary from highly organic to inorganic silts, highly plastic clays, lean clays, sandy silts, and minor amounts of sands.

New Orleans was founded on the natural river levee of the St. Bernard Delta lobe. Natural levee deposits located along the Mississippi River in New Orleans generally range from 8 to 12 feet thick at the levee crest. The coarsest material is found at the levee crest, and consists of stiff silty clays with lenses of silt scattered throughout. The IHNC project area included part of the natural levee near the river. However, most of the acreage of the IHNC project area was originally cypress swamp (Figure 4).

Swamp deposits consist of poorly drained organic clays and muck, with scattered lenses of silt and peat. They have an organic content of less than 30 per cent, a high water content, and a soft consistency. The soft consistency and high water content of the swamp soils contributed to areas of quicksand throughout the area, and created major construction problems for the builders of the IHNC. Another dilemma encountered during the digging of the IHNC was pressurized swamp gas. Decomposed organic remains accumulating under the alluvial deposits became trapped as pockets of insoluble gas, separated from the water-saturated layers.

In 1920, George R. Goethals prepared a paper for the Louisiana Engineering Society that described the building of the IHNC lock foundation through various strata, including layers of quicksand and volatile gas. Included in the paper was a profile of a boring taken in 1918 showing the various substrata encountered in digging the lock foundation (Figure 5). The profile shows clay, sand, and shell strata, and it clearly depicts the sedimentary processes of alluvial and marine deposition.

Elevation and Climate

The present loss of riverine sediments in at and oned delta lobes like the St. Bernard Delta, caused by flood control levees, is an important contributing factor in the gradual decrease in elevation in the delta. Mississippi River water accounts for over 90 per cent of the total input to the region. About 95 per cent of

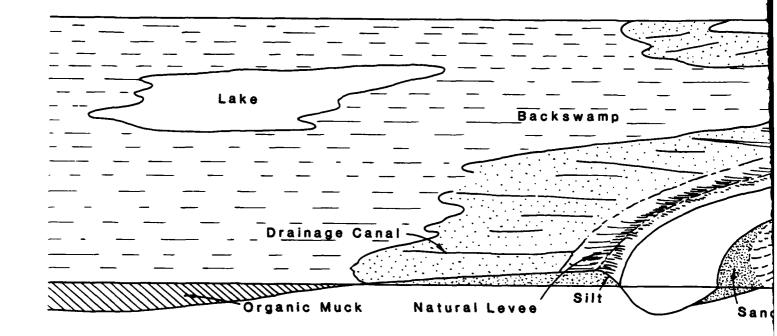
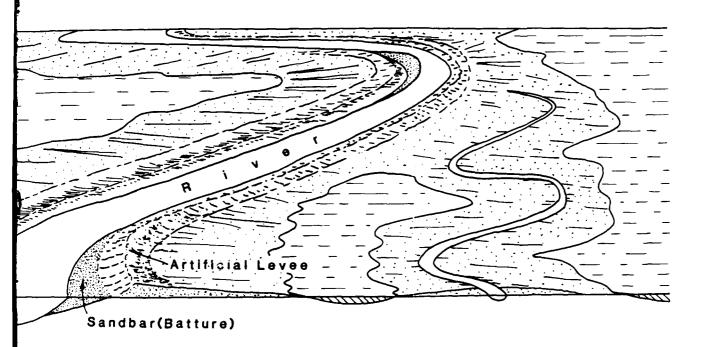
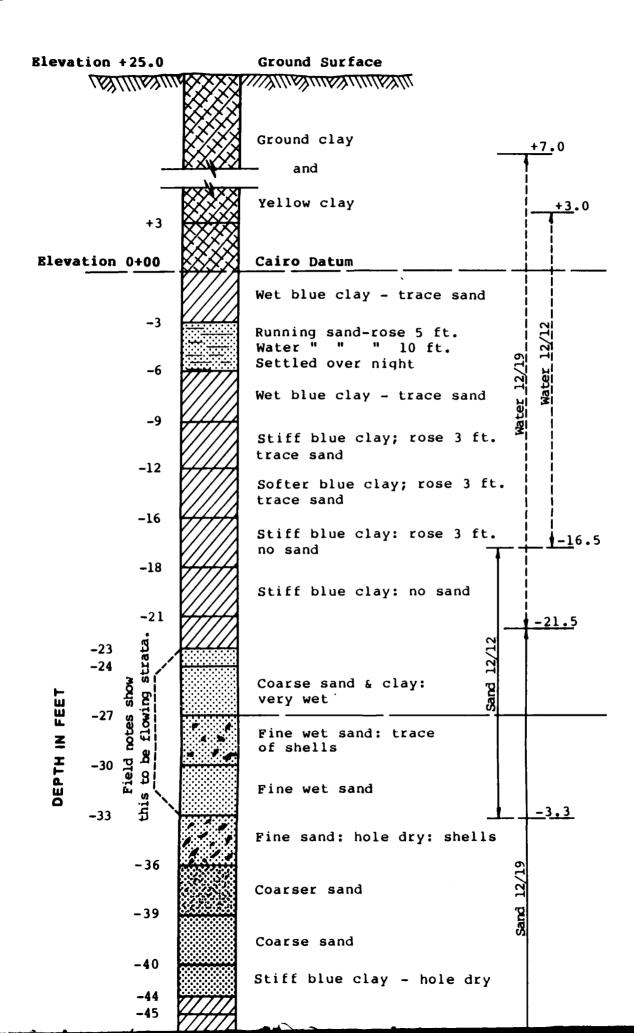


Figure 4. Idealized section of the Mississippi River, showing natural levees, backswamps and human settlement (after Lewis 1976).





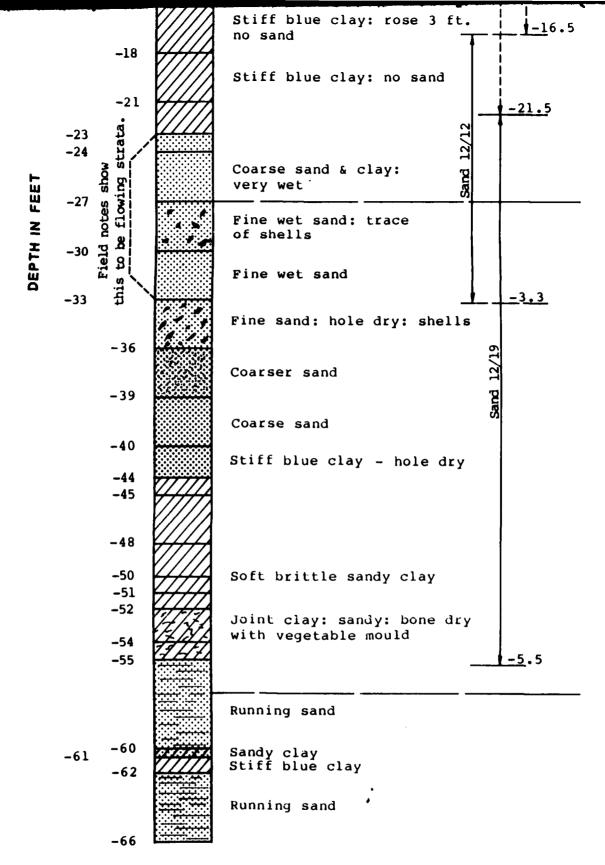


Figure 5. Profile of 1918 boring, showing stratum of the soils encountered during the excavation of the IHNC lock foundation (redrawn from G.R. Goethals 1920:137).

this water and its associated sedimentary material is carried straight to the Gulf of Mexico and over the Continental Shelf (Bahr et al. 1983). Before the 1930s, overbank flooding and crevasses deposited millions of tons of silt into the Modern Delta lobe, including the Barataria and Pontchartrain basins. Without the accumulation of riverine sedimentation, the entire Mississippi River delta east of the Atchafalaya Basin is subsiding (Bahr et al. 1983).

A general principle of delta formation is that the coastline of the most recently abandoned delta lobe regresses most rapidly. This causes substantial sea water intrusion (Becker 1972). Increased subsidence of the abandoned delta lobes and intrusive water from the Gulf of Mexico presently are lowering the elevation of the Mississippi delta area (Adams et al. 1976). According to Holdahl and Morrison (1974), the recent rates of elevation change in this area of the delta indicate that subsidence is occurring at approximately two to four millimeters per year.

Elevation range in the New Orleans area varies from 25 feet above the National Geodetic Vertical Datum (NGVD) along the natural levee crest, to as much as ten feet below the NGVD in parts of the city of New Orleans (Adams et al. 1976). Flanking the Mississippi Deltaic Plain on the northeast is the Pontchartrain Basin (sometimes referred to as the Marginal Basin), which includes part of Lake Pontchartrain. Elevations along the southern coast of Lake Pontchartrain range from the NGVD or slightly below to about ten feet above NGVD (Adams et al. 1976).

Elevation was crucial to the builders of the IHNC because the Mississippi River and Lake Pontchartrain can differ in water elevation depending on the season and weather conditions. water level on the Mississippi River can change as much as twenty feet depending on such factors as snowfall runoff or drought in the Upper Mississippi River Valley. Under normal conditions, the Mississippi River is higher in elevation than Lake Pontchartrain. However, when the river is low, and there are strong southwesterly winds, the lake can be higher in elevation. Therefore, fluctuations in elevation between the river and the lake made it necessary to construct a lock that would accomodate high water levels from either end. The elevations of the Mississippi River and Lake Pontchartrain were crucial to location and design of the IHNC. Since the local weather was one of the determining factors in elevation, weather also influenced the construction of the IHNC project.

The climate in the IHNC study area is subtropical, due to its proximity to the Gulf of Mexico. Winters are usually short and mild, while Summers are hot, humid, and long. Approximate average annual temperatures range from 66 to 69 degrees Fahrenheit.

Average annual precipitation is 49 to 69 inches. The hot, humid, and rainy weather made working conditions uncomfortable for workers on the IHNC project. Severe storms also created serious problems.

Natural climatic catastrophes such as hurricanes, tornadoes, and thunderstorms are a constant threat to the Gulf Coast region, causing flooding and general havoc across the delta. Sudden storms were not uncommon during the building of the IHNC, and as a result, some men lost their lives. During a heavy thunderstorm on July 9, 1920, eight pile driver crewmen took cover under the framework of the pile driver. A lightning bolt struck the pile driver, and all eight men were killed instantly (Stiegman 1971a).

Summary

The IHNC lock is located within one of North America's most unique landforms, the Mississippi Deltaic Plain. The study area is part of the St. Bernard delta lobe, formed over two thousand years ago as alluvial deposits accumulated from the Mississippi River's journey to the Gulf of Mexico.

The IHNC project was constructed through the natural levee deposits along the Mississippi River. Most of the canal, however, was cut through backswamp stretching to the shores of Lake Pontchartrain. The swamp soils provided the IHNC builders with special construction problems such as quicksands and swamp gases. The elevation and climate of the project area also were important natural conditions that directly affected the location, design, and construction of the IHNC.

CHAPTER III

HISTORIC SETTING

Introduction

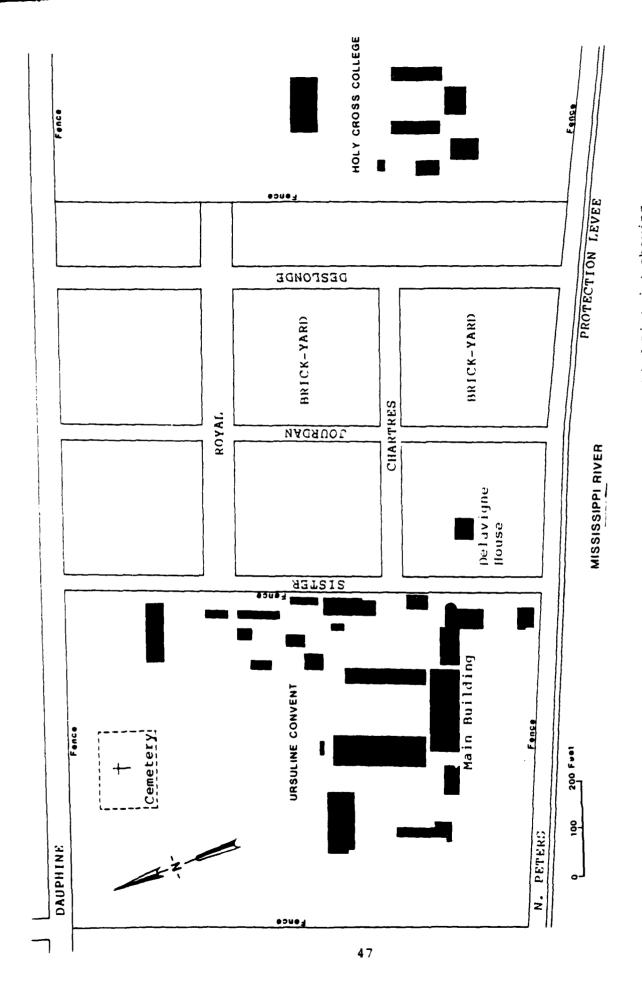
Historic land tenure within the IHNC project corridor began with the settlement of the Faubourg Marigny. Faubourg literally means "small town." Faubourg Marigny was the second suburb or area outside the confines of the old city of New Orleans. The development of this faubourg, from rural plantation life in the eighteenth and midnineteenth centuries to urbanization during the twentieth century, recapitulates the historical development of New Orleans itself. This chapter reviews the history of Faubourg Marigny and the major settlement changes that took place there prior to IHNC construction in 1918.

The IHNC right-of-way impacted areas containing significant historical structures that were situated near the Mississippi River. The Ursuline Nuns maintained a large convent and school, built in 1824, between Kentucky and Sister Streets, and which fronted the river on S. Peters Street (Figure 6). The Brothers of the Holy Cross, who established the campus of Holy Cross College between Deslande and Reynes Streets, also were displaced by the construction of the Industrial Canal. The Oliver and Delavigne Houses were two architecturally significant structures destroyed prior to the building of the IHNC.

The Colonial Period

The history of Faubourg Marigny, as noted above the first faubourg established outside the confines of the original city of New Orleans, began with the original plan of the city designed by Pierre Leblond de la Tour in 1721. Leblond de la Tour's assistant, Chief Engineer Adrien de Pauger, laid out a typical French fortified town; the land immediately outside of the city was reserved as a commons (Wilson 1974). Thus, when the original plantation tracts were granted in the early 1720s, a broad commons was positioned between these plantation tracts and the city.

By the 1740s, however, this suburban area already was developed. Claude Joseph Villars Dubreuil, the Tamous contractor who cleared and built New Orleans' first buildings and levees, was the first to own land referred to as the commons. Dubreuil purchased the Dreux property below the commons in 1743 from Pierre Dreux's widow. This plantation property was known as "La Brasserie," or the Brewery. Evidence suggests that Dubreuil previously had acquired the commons property in exchange for an indigo manufacturing complex he built for



Excerpt from 1877 Plan Book of the Third District showing the Ursuline Convent, the Delavigne House, and Holy Cross College (courtesy Tulane University Library). Figure 6.

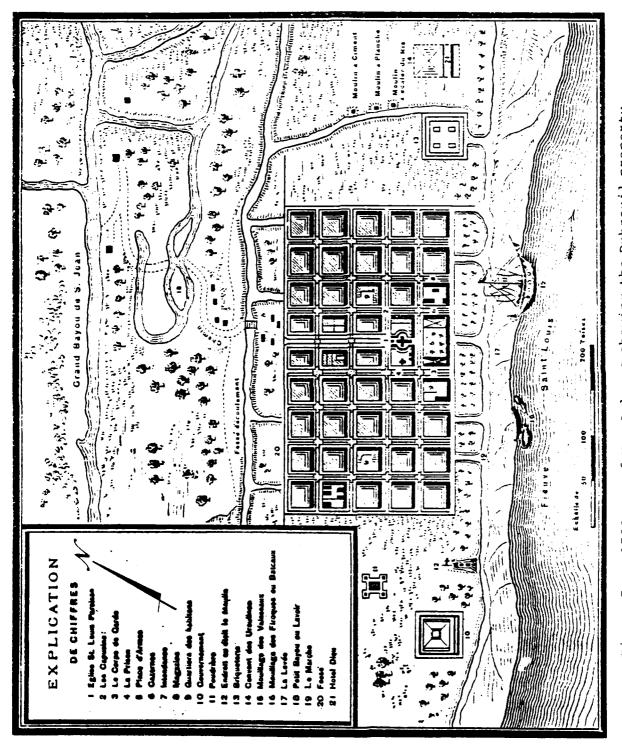
Governor Pierre Rigaud de Vaudreuil. In a letter dated April 5, 1745, to Sieur Henry Greffier, the clerk of the Superior Council, Dubreuil informed Greffier that he was sending him a contract for sale of the "Brasserie" which "Mr. de Vaudreuil and Mr. de Salmon gave him in exchange for the Indigo manufactures and buildings which he made on the Governor's plantation" (Wilson 1946:104).

Archival maps from the eighteenth century show the Dubreuil property, including a canal dug previously on his Brewery plantation. He used the canal for "La Bricterie," the brickyard, and "Moulin a Planches," a sawmill (Figure 7). Dubreuil probably used the materials from the brickyard and the sawmill for the construction of New Orleans' first large buildings, including the Ursuline Convent and the Army Post, now part of the Cabildo (Wilson 1974). Dubreuil used skilled black slaves exclusively for his contracting. The noted architectural historian, Samuel Wilson, Jr., suggests that these highly skilled carpenters, masons, bricklayers, and coppersmiths were the direct ancestors of the numerous Negro craftsmen who settled in the Faubourg Marigny during the nineteenth century (Wilson 1974:3).

Jonathas Darby acquired the adjacent downriver property from Dubreuil, and a M. Coustillas was granted the next downriver concession. It was on the Coustillas property that the Industrial Canal was dug. Coustillas maintained his plantation for at least sixty years. This was unusual because "the most common feature of New Orleans plantations was the ease with which they changed ownership. The brasserie changed hands thirteen times between 1720 and 1810 (Reeves and Reeves 1983:7).

Baron Joseph Xavier Delfau de Pontalba acquired six arpents from the extensive Coustillas concession in 1783. Pontalba was a rich and famous man during the Spanish occupation of New Orleans. Pontalba's son, Celestin, married one of New Orleans' most celebrated historical figures, Micaela Almonester y Roxas. Madame Pontalba, born in New Orleans and educated by the Ursulines, is probably remembered most for transforming the old Place d'Armes into the architecturally noted Jackson Square. The old Spanish structures with sycamore trees that lined the square of the Place d'Armes were removed and the Pontalba buildings were erected.

The six arpent Pontalba concession changed hands several times, eventually reverting to Pontalba, who sold them in 1795 to Jean Baptiste Castillion, who later married Louise de la Ronde, widow of Don Andres Almonester y Roxas. After Castillion's death, Luis Fortin acquired the six arpents in 1811. John McDonogh bought them the next year. That same year, McDonogh sold the upper three arpents to Manuel Andry, son of Luis Andry the architect of Governor O'Reilly's first Cabildo building of 1769 (Wilson 1974). Manuel Andry's first wife, Marianne Thomassin, died in 1817; at that time, the structural



1728 map of New Orleans showing the Dubreuil property (13) and canal (courtesy Historic New Orleans Collection). Figure 7.

improvements of the plantation were described as containing "a master house with an upper story, constructed of brick and roofed with shingles and various other buildings" (Wilson 1946).

Francis Duplessis acquired the lower three arpents of the former Pontalba plantation from McDonogh in 1812. This plantation became the site of the Ursuline Convent when the nuns moved from their historic French convent on Chartres Street (Wilson 1974). The eventual move in 1824 by the Ursulines from their original 1734 location to the Faubourg Marigny was not without its controversies.

As early as 1819, the question of opening the streets, which had been obstructed by the convent property and by the Government barracks, had come up at the City Council session. The Council,

resolved that the Mayor shall write to General Ripley to inform him that the City Council contemplates to extend the opening of Conde [Conti] and Hospital Streets, consent that said streets be extended through the United States properties which are in line with said streets (Wilson 1946:629).

The Ursulines resisted the city's efforts to cut new streets through their property until 1820, when, on July 12, the extension of Conde Street through property owned by the United States was agreed to, and the Ursuline Sisters were notified that the extension of this street was to begin immediately (Wilson 1946:630). The Ursulines, having agreed to allow passage through their property on Chartres and Hospital Streets, decided with the approval of Bishop DuBourg, to erect a new convent on a site several miles farther down the river on the plantation which they had purchased on November 26, 1818, from Francis Duplessis.

On March 25, 1823, the Ursulines entered into a contract for \$54,200.00 with architects and contractors Gurlie and Guillot. Before the contract was completed, it had increased in value to \$83,172.00. This was due to the addition of other buildings, including a left wing for \$17,972.00 added September 12, 1823, and a chapel constructed in 1829 (Wilson 1946). The contract specified:

Gurlie and Guillot promise and obligate themselves to construct and erect on the plantation of the community of the Ursuline Ladies, situated in this parish, two miles distan' from this city and on the same side and at the spot which will be indicated to them a building of brick and of two stories (Wilson 1946:631).

In 1824, the two-story main building was completed. Surrounded by a two-story gallery with square cemented brick columns on the second floor, Gurlie and Guillot put jalousies between the columns of the second floor gallery facing the river. An unusual third story or attic was added later. It was "ornamented with a lyre design in stucco, with a scalloped sort of stucco cornice and a central pediment with a plaster sunburst" (Wilson 1946). Even more curious was the Baroque clock tower surmounting the low-pitched hipped slate roof (originally of shingles). Wilson observed that:

this clock tower and the attic story which was built out over the gallery over the line of the columns, are of such vastly different character than anything else in New Orleans of that period that it must be assumed that they are later additions (Wilson 1946:643).

Two-story wings with two-story galleries were added behind the main building; they were quite similar to the original building as it must have been before the addition of its attic story. The roof was steeply pitched with many dormers. The court was closed on the fourth side by a wooden picket fence with wooden gates.

The chapel was completed in 1830; it stood at the lower end of the main building. A Baroque pedimented end, facing the Mississippi, was added to an open arcade on the convent side. The entire Ursuline complex is shown in Figure 6. The Ursuline tract is shown in Figure 8.

On the lower side of the convent stood the handsome Delavigne house, purchased by Barthelemy Jourdan in 1819 from Thomas L. Harmon. This house may have been built between 1800 and 1810, when most of the property was owned by J.B. Castillion (Wilson 1976). This two-story plantation house was demolished prior to construction of the Industrial Canal.

The Nineteenth Century

Economic change was gradual in the study area during the early part of the nineteenth century. Pierre Marigny purchased the Dubreuil concessions from Gilbert Antoine de St. Maxant in 1800. The city of New Orleans designated its first faubourg as "Faubourg Marigny" in 1806. Industry was light; a sawmill, local brickyards, and distilleries were the important commercial enterprises in the area. Pierre Marigny maintained the canal built by Dubreuil, known then as "Marigny's Canal" (Figure 9, Carlos Trudeau's 1875 copy of a 1798 map of New Orleans shows that a

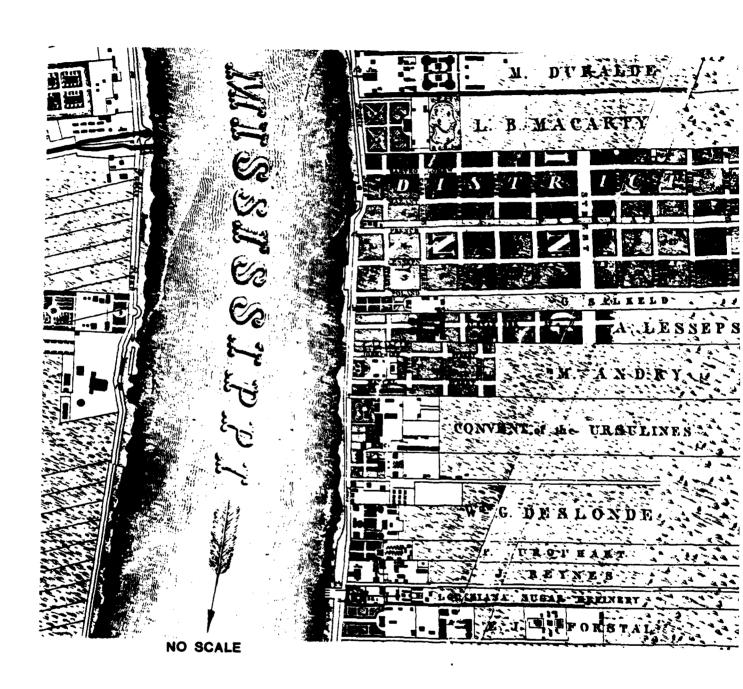
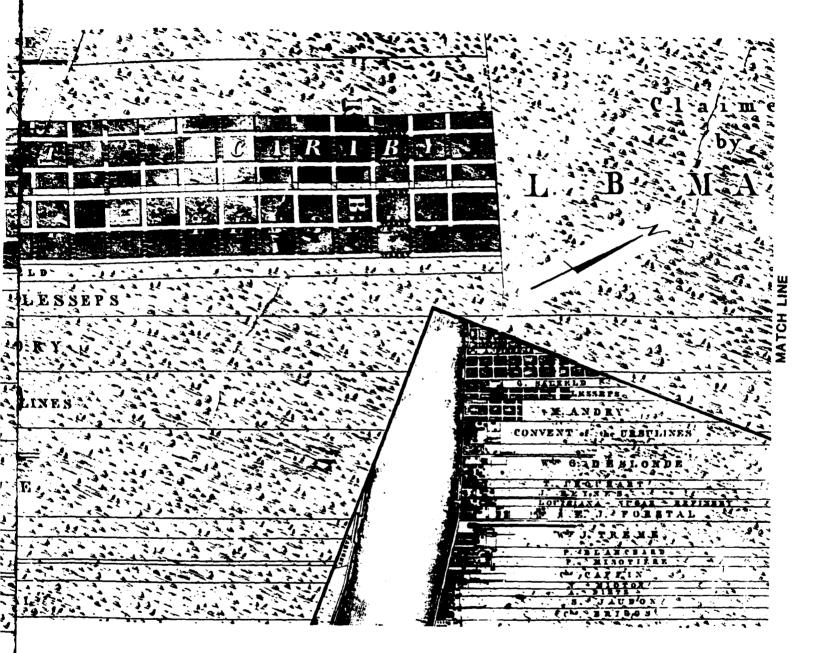


Figure 8. Excerpt from Zimpel's 1833 Plan of New Orleans showing the Ursuline tract.



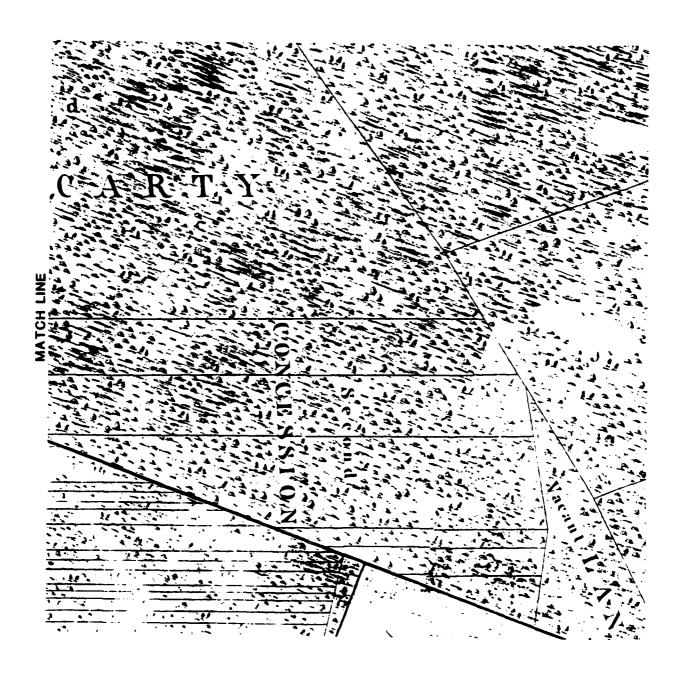
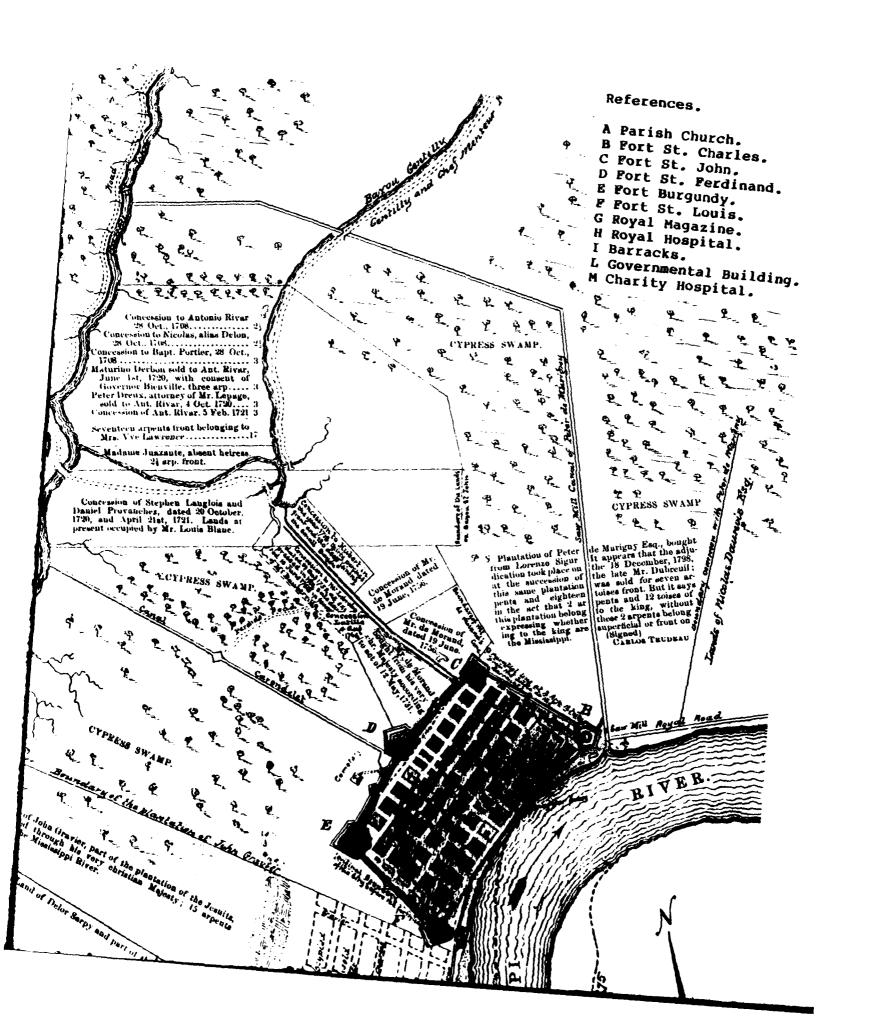


Figure 8, continued.



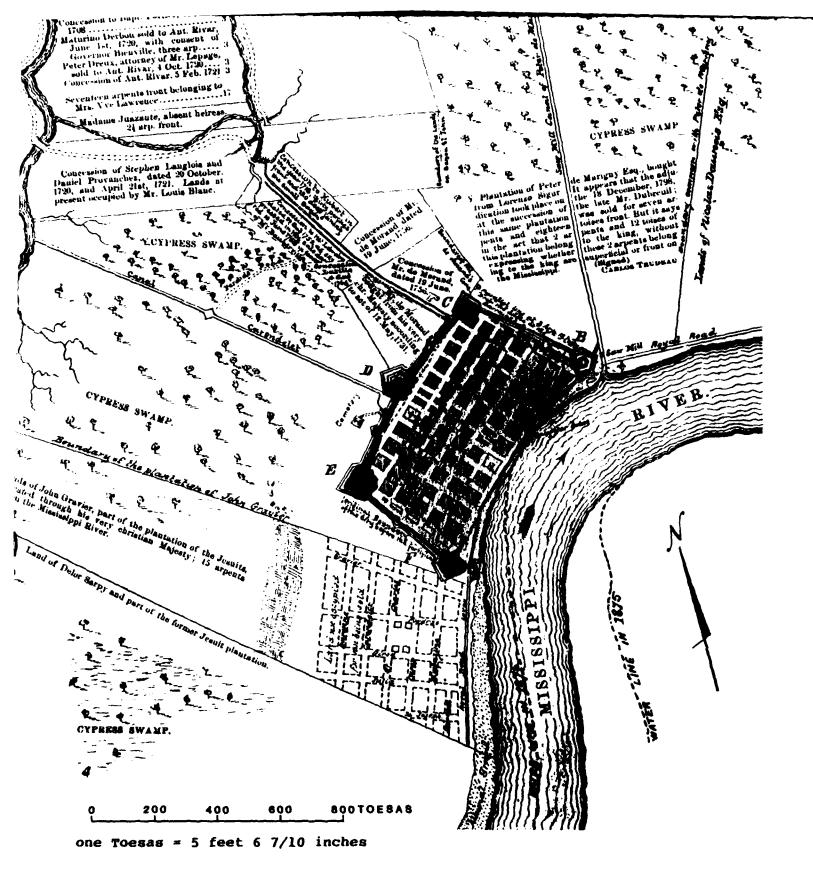


Figure 9. Carlos Trudeau's 1798 Map of New Orleans (recopied in 1875) showing the Marigny Canal (Courtesy Historic New Orleans Collection).

Collection).

sawmill was still in use on Marigny's canal. Downriver, John Baron owned a distillery on his five arpent property (upriver from the Ursuline tract), of which he sold four arpents to the Charity Hospital in 1818. David Olivier purchased Baron's one arpent distillery land in 1820, and two arpents from John Carriere in 1819. Olivier continued to operate the distillery until he sold the two arpent tract to Etienne Carraby in 1833. The sale included, "all the rights to the batture [and] also the buildings of any kind, fences, sheds, and an old distillery with the two stills mounted thereon" (COB X, Folio 141, Orleans Parish Courthouse). The Carraby property, including the stately Olivier House, eventually was sold to the Catholic Orphans' Association in 1840.

In 1859, the congregation of the Holy Cross acquired the property running from Reynes Street above, to the Louisiana Sugar Refinery below, adjacent to Barthelemy Jourdan. The Holy Cross Brothers for a time operated the St. Mary's Orphanage in the old Olivier House. The Olivier House, like the Delavigne House, was one of the finest suburban residences below New Orleans (Wilson 1974). The improvements were described as "a beautiful brick dwelling of two stories; two other brick buildings used for kitchens and servants quarters; stable and coach house" (COB DD, Folio 216, Orleans Parish Courthouse).

The Holy Cross Brothers established St. Isadore's College from their 1859 acquisition. St. Isadore's, which became Holy Cross College, was opened in 1879 and chartered in 1890. As shown in Figure 6, the campus of Holy Cross included a school building, two dormitory buildings, a rectory, a chapel, and a laundry house. All of these structures were demolished prior to the construction of the Inner Harbor Navigational Canal.

The Twentieth Century

From the turn of the twentieth century, the study area in question evolved wholly into an industrial area. Figure 10 is a 1911 map of the proposed development of the IHNC by civil engineer John H. Bernard. The area was labeled "Industrialville." As a consequence of development, all significant structures within the IHNC impact area subsequently were destroyed except the Ursuline Convent.

The Ursuline Convent in the Faubourg Marigny actually was torn down prior to a massive levee setback on the Mississippi River in 1911, seven years before the building of the Industrial Canal. As early as 1907, it became evident that the construction of a new levee of unprecedented proportions would necessitate the demolition of at least the main building fronting the river.

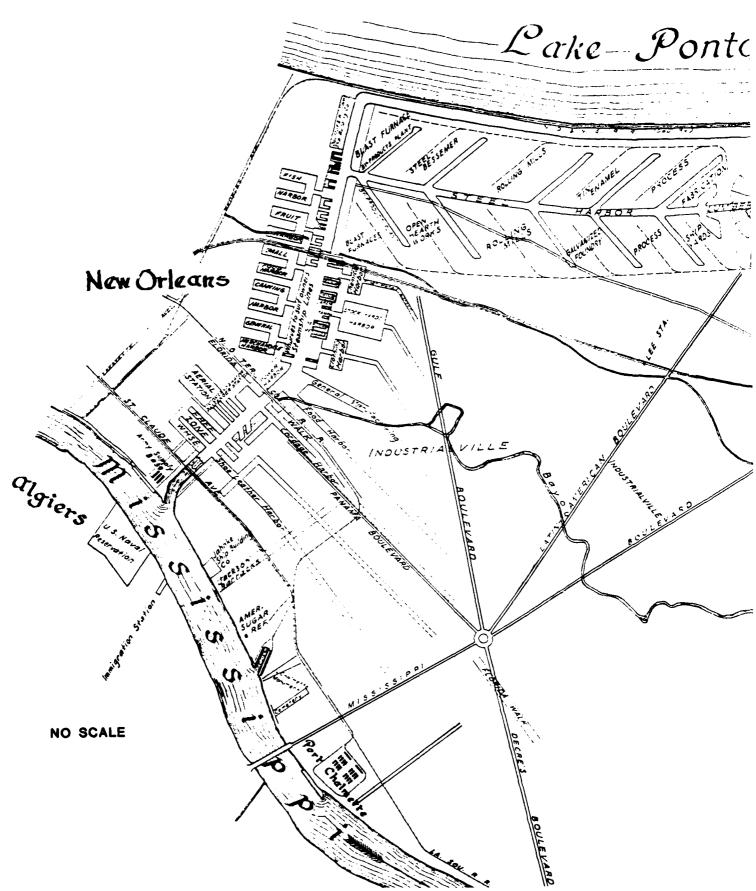
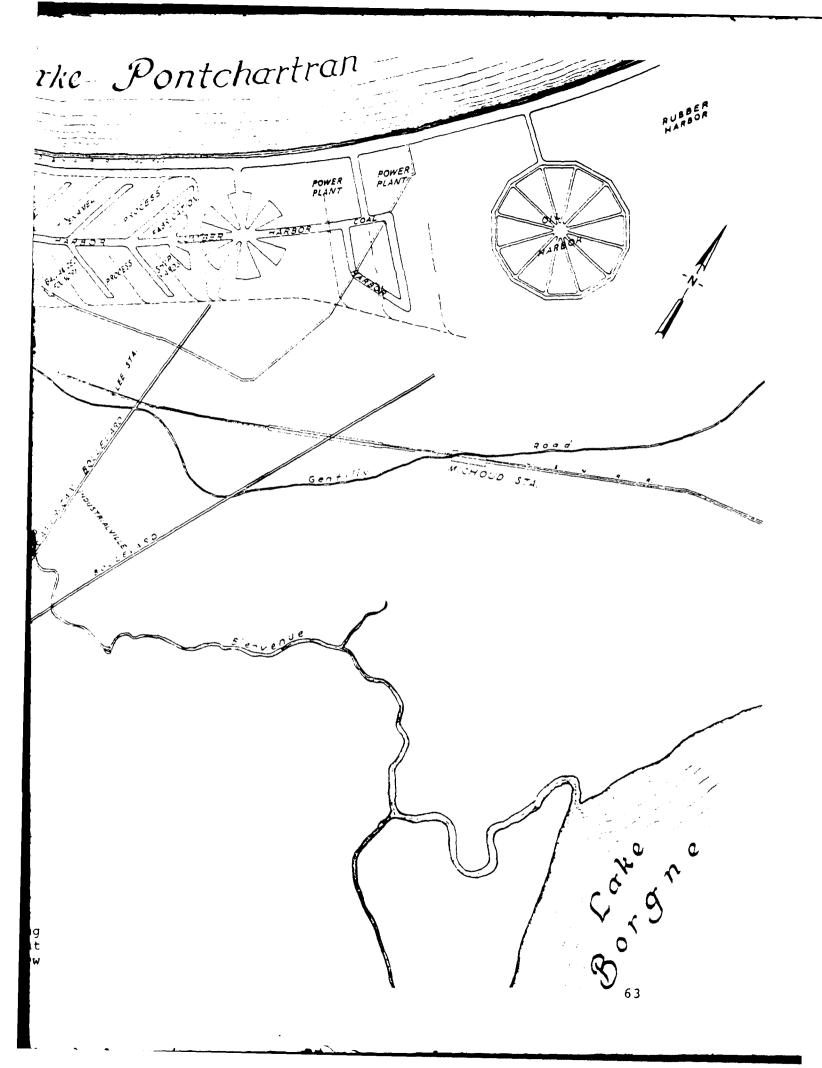


Figure 10. 1911 map by Civil Engineer John H.Bernard, showing proposed developments of the IHNC, and the adjacent land called Industrialville (Courtesy Historic New Orleans Collection).



Subsequent negotiations with the New Orleans Levee Board and Mayor Martin Behrman during the next several years concluded that the entire school and convent would have to be removed. The Ursulines donated their entire land to the city:

The free gift, of such a large strip of land by the nuns, the Mayor regards as a very striking example of public spirit, and the fact that their property will be benefited does not at all detract from their large-mindedness (The Picayune, July 22, 1911).

The Ursuline Convent subsequently moved to its present location at State Street in the Uptown section of New Orleans. The cemetery, which was on the grounds of the old Convent, also was moved to the new location.

The selection of the uninhabited Ursuline Tract as the right-of-way for the IHNC was left to the Commission Council of the City of New Orleans. To prevent real estate profiteering, the selection of this route was secret (Stiegman 1971a). On March 18, 1918, the Commission Council recommended that the Third Municipal District within the area bounded by Manuel and Reynes Streets, north from the Mississippi River to Florida Walk, and then to Lake Pontchartrain either by a north, northeasterly, or northwesterly direction, be selected as the site for the canal.

Local Navigation Projects

During the eighteenth and nineteenth centuries, the proximity of the Mississippi River to Lake Pontchartrain at New Orleans occasioned a number of aborted attempts to link the two with a man-made waterway. The first navigation canal in the New Orleans area was on the other side of the river. In 1736, Claude Joseph Villars Dubreuil, seeking to eliminate the need for portage, enlarged a drainage canal in order to provide a navigable passage between the Mississippi River and Bayou Barataria. This canal was apparently the forerunner of the present-day Harvey Canal (Goodwin et al. 1985).

The first canal on the east bank was initiated by the Spanish governor, Francisco Luis Hector, Baron de Carondelet in 1794. This canal proceeded along a natural bayou which was named after the Spanish fort located at the mouth of the bayou--Fort St. John. However, Bayou St. John provided a navigable waterway for only half the distance to the City of New Orleans. Carondelet's plan was to link the city to the lake by digging a canal along the present route of Orleans Avenue, from the bayou to the ramparts of the city (appropriately known today as Rampart Street). At that time, the

ramparts were only six blocks from the Mississippi River. Carondelet intended that the canal be used specifically for navigation, and he anticipated that the King of Spain would provide financial assistance. However, Spain's involvement in the War of the First Coalition (against France) occupied both the King's attention and his resources. As a conciliatory gesture, the King sent Carondelet a number of slaves to aid in excavation. Carondelet also prevailed upon some New Orleanians to send their slaves to help, arguing that the canal would drain the stagnant water from behind the city and thereby improve public health. At the city end of the canal, a turning basin was excavated for vessels using the canal. The Carondelet Canal, later known as the Old Basin Canal, was completed in November, 1795, with a minimum width of fifteen feet. Thus, a navigation canal had been realized, although it fell short of connecting the great bodies of water. Nevertheless, as the canal was improved it became an important commercial waterway. A century later, in 1902, it had 1,371 vessel arrivals. Its banks hosted a variety of businesses, including three lumber companies, two ice companies, a barrel company, a fireworks company, shipyards, and cooperages. Clearly, a navigable waterway provided an attractive site for businesses that valued cheap water transportation.

The next canal to be excavated was the New Orleans Navigation Canal (New Basin Canal), begun in 1833. Like the Carondelet Canal, it was seven miles long and terminated at Rampart Street, about six blocks from the river. Its completion in 1835 was accomplished despite serious outbreaks of cholera and yellow fever among the workers. This canal was even more prosperous than the Carondelet Canal, and it soon acquired a majority of the lake trade. In 1914, it recorded 3,450 vessel arrivals. The New Basin Canal provided a route for a variety of products including lumber, brick, sand, shell, shingles, staves, logs, oysters, produce, cotton, and wool.

Canals: Then and Now

Perhaps the most significant canal project proposed during this period was one that was not built. On October 12, 1826, the Engineer Department of the Department of War directed the Board of Internal Improvement:

to make a general report upon the contemplated Mississippi and Lake Pontchartrain Canal, setting forth the dimensions and probable cost of the same, its object, utility, and advantages, in a commercial as well as in a military point of view (H.Doc. 1331, 1827:7).

On December 13, 1826, the House of Representatives passed a resolution directing that the report be completed and forwarded to them. Topographical Engineer Captain William Tell Poussin was charged with mapping the entire area, and with examining possible routes for such a canal.

The first route Poussin considered was the extension of the Carondelet Canal to the river. This route was found to be wholly unsatisfactory. The shoaling at the mouth of Bayou St. John, and the intricate navigation of the bayou section of the canal, were major obstacles. There were other problems, such as the difficulty and expense of cutting a canal through the center of the city. As Poussin's report summarized,

this work [the Carondelet Canal], which belongs to a company, cannot, in its present condition, fulfill the object contemplated; its continuation through the very heart of the city, would be a great nuisance; and, at the same time, would involve large expenses for purchase of ground. This route must be avoided (H.Doc. 133, 1827:8).

A second alternative, above the city in the Faubourg St. Mary, was rejected because the river deposited such large amount of silt in that area that it would have been impossible to keep the entrance to the canal open. Furthermore, "the ground of new formation, of no homogeneity and compactness, would oppose, to the erection of a lock, difficulties almost insuperable" (H.Doc. 133, 1827:8).

A third proposed route commenced at Jackson Square and proceeded present-day Elysian along Fields Avenue. Topographically, this route was the most advantageous of those examined. However, like the extension of the Carondelet Canal, the cost of land under this option would have been very high. It also would have interfered with the extension of wharves along the lower part of the city. And, like the first alternative, it would have cut through part of the city (Faubourg Marigny), becoming "noxious to the thoroughfare of this district" (H.Doc. 133, 1827:9). Nevertheless, Poussin believed that the advantages of this route outweighed the disadvantages. He thought that it would provide the most favorable geologic and topographic conditions for the canal, that it would accommodate trade, and that it would improve the health of the citizens by draining water from the marshy land of the city.

The fourth, and final, route to be considered was two miles below New Orleans. This route would have been about one-half mile longer than the Faubourg Marigny route. On the other hand, it would have crossed cheaper land. In addition, it would not

interfere with the traffic of the city. But, the report argued, it would not accommodate the trade of the city as well; it would require ascending navigation from the canal to the city; and, the excavation would be more expensive because of the preponderance of marshy ground.

The report concluded that the Faubourg Marigny route was the best alternative because of "the better accommodating of the trade, and the improving of the health of the city" (H.Doc. 133, 1827:10). The report also suggested the specifications that such a canal would require. Because the Mississippi River is generally much higher than Lake Pontchartrain, it would be necessary to have a lock at the river end of the canal. Because the northeasterly winds combined with a low stage of the river could send the water in the opposite direction, a lock also was recommended for the lake end of the canal. Poussin, along with Brigadier General S. Bernard of the Board of Internal Improvements, recommended a canal seventy feet wide and nine feet deep. The technical design of the lock, as recommended, probably would have been impossible to execute in light of subsequently discovered information about the composition of the land in which it was to be excavated. The report recommended a depth of 24 feet, 10 inches, below the crest of the levee:

It will necessitate a pit of great depth, and a cofferdam of strength and solidity to shelter the work during its construction; but the ground bids fair to an easy excavation, and will afford materials of the very best kind to make the cofferdam perfectly tight (H.Doc. 133, 1827:11).

Because of the unstable subsurface conditions, a strong foundation would be necessary to support the weight of such a structure. Three gates were required: one on the lake side, and two on the river side "for greater security" (H.Doc. 133, 1827:12). The lock would be 40 feet wide and 130 feet long. The lock at the lake end of the canal would be of the same dimensions. The estimated cost of the entire project was \$974,304.00.

The final section of the Poussin report examined the "utility and advantages of the canal" (H.Doc. 133, 1827:15), which, according to the authors, were several. A primary consideration for the War Department was the fact that the canal would allow vessels to leave the river, proceed through the lake, and then follow the coast as far as Pensacola. The result would be safer and surer water communication with the naval installation at Pensacola in time of war. This national defense argument occupied most of the space in this section of the report, although reference again was made to the trade advantages accruing to New Orleans as a

result of the canal.

Clearly, this report identified many of the issues which would lead to construction of the Inner Harbor Navigation Canal ninety years later. Equally apparent, however, is the fact that nineteenth century engineering technology would not have been adequate to deal with the problems which would have attended this operation. It would require the best engineering knowledge of the day to cope with these problems almost a century later.

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CHAPTER IV

UNITED STATES NAVIGATION HISTORY

Internal Improvements

In 1815, about 8,400,000 people lived in the United States. Out of every 100 persons, some 37 lived in the South Atlantic States, 48 in the Middle Atlantic and New England states, and 15 in the western states and territories. This population was predominantly rural; only about 7.2 per cent lived in cities of 2,500 or more, and over a third of them lived in the two giant cities of New York and Philadelphia. (Sixteenth Census of the U.S.: Population 1:14-20.). The United States of that time possessed vast but largely untapped natural resources; its nearly 1,800,000 square miles, after the annexation of Florida in 1819, awaited a transportation revolution to open the country to economic utilization and further settlement.

The impetus for this revolution would be generated by the interests of the cities, whose chief business was commerce, and whose leading citizens were merchants. Yet in 1815, "every city seemed to face the sea, the direction from which came not only the needed products of every land but the news of distant nations and markets" (Taylor 1951:10). American producers and consumers, about 93 per cent of whom lived on farms or in small towns, were often only marginally connected to these major commercial centers.

Roads, though extensive, were poor; often little more than paths through the forest, roads of the period were alternately mud and dust. Enthusiasm for improved land transportation followed the War of 1812. The British blockade of the Atlantic coast had forced transportation onto overland routes, and the shortcomings of such routes soon became clear. For example, one wagon carrying cotton cards from Worcester, Massachusetts, to Charleston, South Carolina, took seventy-five days. Good roads for troop movements also were necessary for the national defense. The "agitation for better roads also arose from the generally improved commercial conditions following the war" (Taylor 1951:18). Farmers had waraccumulated surpluses to get to seaports, seacoast merchants and manufacturers had products to sell in the interior, and the westward movement of the population was rapidly increasing. Political unification, commercial expansion, and military defense cried out for improvements to transportation. The scope of these transportation requirements, both present (1815) and potential, was immense. Local planning and funding seemed no longer to be enough. State, regional, and even national involvement and sources of revenue were being considered.

One such proposal, anticipating these needs and submitted to Congress in 1808, was the plan of Albert Gallatin. As Secretary of the Treasury under Jefferson, Gallatin called for Federal financing of a number of highways and canals which would improve transportation to and from inland markets and along the East Coast. Despite President Jefferson's support, Gallatin's plan never was implemented. Embargo and war had reduced government income and claimed greater attention. The plan also raised questions as to the constitutionality of federal projects either entirely within individual states or designed to benefit particular regions. In fact,

until 1860, the federal government funded only one major highway (the National Pike from Cumberland, Maryland, to Wheeling, West Virginia), and had given limited support to a few other transportation projects. However, it had never implemented any comprehensive plan (Puth 1982:112).

However, the federal government had continuously debated the subject, and despite financial concerns and constitutional scruples, approved grants to aid in building specific roads, canals, and railroads. In fact, "the average annual appropriation of federal government for internal improvements increased with each administration from Jefferson through Jackson" (Taylor 1951:20,21). Historian George Rogers Taylor claimed that the real obstacle which defeated a national system of internal improvements was not, finally, the argument over constitutionality, but, "the bitter state and sectional jealousies which were wracking the new nation" (Taylor 1951:21).

Whether federally funded or financed by state, local government, or private capital, "internal improvements" in transportation were being made. One form, the turnpike, enjoyed a boom in construction in the two decades following the War of 1812. Yet it did not last. Most turnpikes, though valuable, failed to return a profit. Their inability to provide the means of cheap transportation over considerable distances sealed their doom. It was left to the canal and railroad to provide what the turnpike could not: economical long-distance transportation.

In 1816, only about 100 miles of canal had been constructed in the United States; only three operating canals were more than two miles long. The Middlesex, the longest canal at 27.25 miles, tapped the Merrimack River to bring the products of New Hampshire to Boston Harbor. In South Carolina, the commerce of the Santee River was brought to Charleston by the Santee and Cooper Canal. Small boats passed between Norfolk, Virginia, and Albemarle Sound, North Carolina, by the Dismal Swamp Canal. But none of this

construction had spurred further canal building. The primitive state of canal engineering, the heavy expenditures of capital, and the failure of existing canals to return a profit to investors all contributed to a reluctance to build (Taylor 1951:32).

The Canal-Building Era

The construction of the Erie Canal was an act of faith. With Governor DeWitt Clinton as its most powerful promoter, work began on the canal in 1817, soon after passage of a bill by the New York legislature authorizing its construction. Extending through some 364 miles of unsettled wilderness, it would link Albany with Buffalo. This would be by far the longest canal in the world, and engineering problems "greater than any previously solved in canal construction had to be surmounted in the building of its locks and aqueducts" (Taylor 1951:33). Constructed under the direction of two lawyers, the canal proved to be a massive on-the-job training project. Some sections did not even hold water, a situation resolved by the invention of waterproof cement. Overcoming the obstacles which both nature and their lack of training put in their way, the builders completed the canal in 1825. With it, New York City became the only Eastern seacoast town with an all-water route to the interior. As Puth (1982:117) noted,

The canal was an important factor in New York City's rise to preeminence among East Coast commercial centers, and it also contributed greatly to the growth of Buffalo, a transfer point where cargo was shifted from lake vessels to canal barges.

The Erie Canal proved to be far more than "Clinton's Big Ditch," as its detractors called it. Even before it was completed, it set off a nationwide craze for canal building. The Erie itself was widened from 40 to 70 feet and deepened from four to seven feet, a task not completed until 1862. But few, if any, of these subsequent canals were as successful as the Erie, and some of those were feeders to it. Despite its challenges and difficulties, the Erie Canal succeeded because it linked a major seaport with a rich and well-populated hinterland, and because its generally level terrain made travel relatively quick and convenient. Many of the other canals faced greater difficulties and fewer advantages and rewards.

The canal building fury which gripped the country in the years after the War of 1812 was affected, too, by Speaker Henry Clay's articulation of what would come to be known as the "American System" which, among other things, called for government promotion of "internal improvements." In the spirit of the American System,

and out of concern for the national defense, Secretary of War John C. Calhoun issued his "Report on Roads and Canals" in 1819. In some ways an update of Gallatin's 1808 plan for a national system of transportation, Calhoun further suggested that military engineers survey and construct important roads and canals (Hill 1957:24). The military engineers he referred to, of course, were members of the U.S. Army Corps of Engineers.

Created by an act of Congress on March 16, 1802, the Corps of Engineers "devoted its attention almost solely to coastal defenses and its military school [West Point] prior to the War of 1812" (Hill 1957:5). After that war, and with the problems of defending the country made more clear,

Congress and the administration decided to employ a foreign engineer to aid in planning an adequate system of fortifications... Upon the recommendation of General Lafayette and Albert Gallatin... the government selected General Simon Bernard, one of Napoleon's best engineers. On November 16, 1816, Madison signed Bernard's commission attaching him to the Corps of Engineers as assistant engineer with the rank of brigadier general (Hill 1957:6).

On that day, the War Department established the Board of Engineers for Fortifications whose members would include General Bernard, Colonel William McRee, and Lieutenant Colonel Joseph G. Totten.

The procedures adopted by the board for planning fortifications included securing surveys and topographical data for use in locating and projecting defense works. Planning by the board also included recognition of the importance of inland communications to expand domestic trade, supply the army and navy, and concentrate troops at points of attack. Indeed, Secretary of War Calhoun emphasized in his 1819 report that commerce, military defense, and inland transportation were closely allied, especially at the great estuaries and harbors where land and water communications met (Hill 1957:9).

Since the President and the Secretary of War both saw the planning of the national defense as comprehensive, the Board of Engineers for Fortifications inevitably got involved in the canal craze then sweeping the country. Canal schemes in Pennsylvania, Delaware, New York, and New Jersey all received aid from Army engineers in 1823.

A New Jersey to New York project, the Morris Canal, which would bring coal from the Lehigh Valley and iron from the ironworks in New Jersey to "the flourishing manufacturing village" of

Patterson and to New York City, received Calhoun's blessing and the board's aid because of the great advantages it would bring to the two states and to the nation. In their report on the proposal, Bernard and Totten wrote:

Of all the means which human ingenuity has devised for facilitating communications between different parts of a country, canals occupy, at the present day, the highest rank, and when well planned and judiciously located, they not only become sources of individual wealth; but they diffuse prosperity over extensive regions, and result in economy and advancement to the nation at large (Bernard and Totten 1823:1).

The two Army engineers further called for public support of canals that would produce general benefit but that would not be profitable private ventures. "Their report illustrated the strong desire of the army engineers to promote internal improvements" (Hill 1957:33).

President Monroe endorsed this view that same year when he recommended that army engineers be used to survey the proposed Chesapeake and Ohio Canal. He supported the project because of the great economic, military, and political benefits it would provide. Soon thereafter, Congress formalized the General Survey Act of 1824, directing the Corps of Engineers to make surveys for civil works and canal surveys for states and chartered companies.

The purpose of the General Survey Act was to prepare a program of appropriations for nationally important roads and canals, with federal subscription to stocks of enterprises undertaking them (Turner 1906:232-33). The Act embodied Monroe's view: by 1824, the prevailing opinion was that Congress could finance internal improvements of national value but could not establish control over them. The Act did not authorize construction of a national system of internal improvements, it merely instituted a general scheme for the surveying and planning for them (Hill 1957:45-49).

President Monroe created the Board of Engineers for Internal Improvements to administer the General Survey Act. He named General Bernard, Colonel Totten, and John L. Sullivan, a civil engineer, to the board. At the end of 1824, Monroe, in his Annual Message, spoke of the work already done by the board and emphasized the enormous task yet remaining in surveying and planning civil improvements. During its eight years of life (in 1831 the Topographical Bureau assumed the work of the board), the Board of Internal Improvements examined all major routes proposed by Gallatin and Calhoun,

and many more besides. It made more surveys for canals than roads, but with the administration's approval it brought railroads within the scope of the General Survey Act. It used civil engineering as the basis on which to plan a comprehensive scheme of roads and canals worthy of Federal support. Through this surveying it also gave direct impetus to state and private undertakings (Hill 1957:59-60).

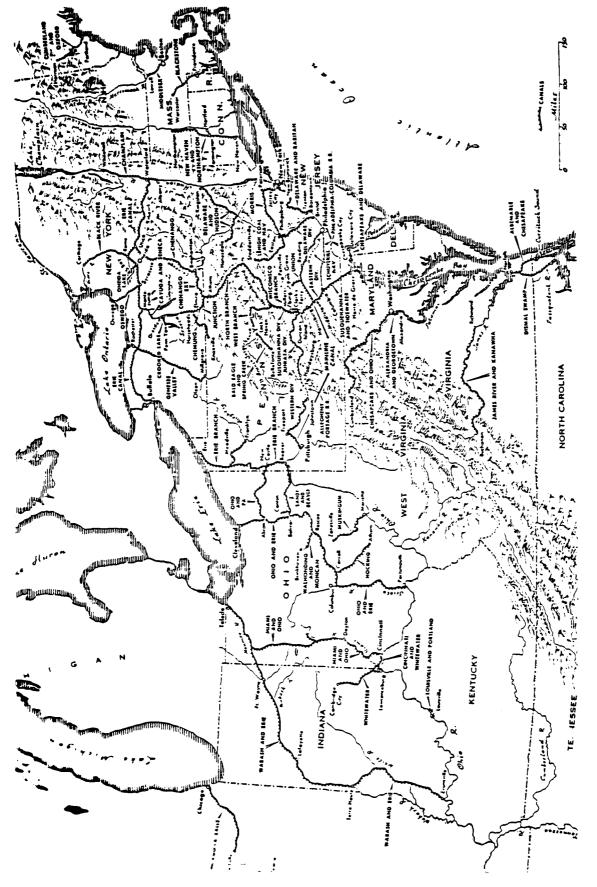
Federal, state, and private involvement produced a vast maze of canals during the great canal-building period, 1815-1860 (Figure 11). Actually, construction came in three waves. During the first wave, lasting from 1815 to 1834, and peaking in 1828, some 2,188 miles of canal were dug. The second wave, which accounted for 1,172 miles and peaked in 1840, went from 1834 to 1844. The third wave, which peaked in 1855, lasted from 1844 to 1860. During that time, some 894 miles of new construction were completed, though nearly as many miles of canal may have been abandoned then, too. A grand total of 4,254 miles of canal were built during the three cycles of canal construction, 1815-1860 (Goodrich, ed., 1961:172-173; Puth 1982:118).

Responding less to national plan than to regional rivalry, three types of major canals were built during this early nineteenth century period of canal-building:

(1) those designed to improve transportation between the upcountry and tidewater in states bordering on the Atlantic from Maine to Virginia; (2) those, like the Erie, designed to link the Atlantic states with the Ohio River Valley; and (3) those in the West which were planned to connect the Ohio-Mississippi system with the Great Lakes. In New York, Pennsylvania, and Ohio the main line canals were supplemented by an extensive system of branches or feeders (Taylor 1952:37).

Three of the major tidewater canals were in New England: the Cumberland and Oxford Canal, from Sebago Pond to tidewater near Portland, Maine; the Blackstone, connecting Worcester, Massachusetts, with Narragansett Bay in Rhode Island; and, the New Haven and Northampton, joining those cities in Connecticut and Massachusetts. Only the first succeeded past the 1840s.

Following the success of the Erie Canal, a number of major waterway systems were built in the Middle Atlantic States; three in eastern Pennsylvania extended to the Delaware River, connecting with canals built across New York or New Jersey. A fourth, the



Locations of various Federally funded canals in the northeastern United States (from Goodrich 1961:183-84). Figure 11.

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Delaware Division Canal, linked Easton with Bristol by paralleling the Delaware River on the Pennsylvania side. Known as "the anthracite canals," the chief traffic on these waterways was coal being delivered to Philadelphia and New York. The three northernmost canals were all privately owned. The Delaware and Hudson Canal in northeastern Pennsylvania, completed in 1828, enjoyed many prosperous years before peaking in 1872. Just south of it was a waterway system consisting of two privately owned canals, the Lehigh and the Morris. The Lehigh, completed in 1829, carried tremendous tonnage. In 1860, its peak year, two thousand canal boats carrying over one and a third million tons of traffic traveled its waters. The Morris, connecting the Lehigh with Newark Bay, was shallower than the Lehigh and could not accept its larger boats. Later enlarged, it operated with some success until after the Civil War. Below the Morris Canal was the Delaware and Raritan Canal in New Jersey. Despite bad management, this canal actually carried greater tonnage for a few years than did the Erie (Taylor 1951:38-41).

Three canals, not, strictly speaking, belonging to the anthracite group but important nevertheless in the coal trade, were the Union, the Susquehanna and Tidewater, and the Chesapeake and Delaware. The first two linked other important waterways in Pennsylvania, and the third, though outside the state, supplemented its waterway system by providing an inland shortcut for shipping between the Chesapeake and Delaware Bays (Taylor 1951:41-42).

Two tidewater canals in Virginia and Maryland, both designed to cross the Appalachian divide and connect with the Ohio River, failed in that ambition and in profitable return, though not in importance to the public weal. The James River and Kanawha Canal extended nearly 200 miles; it did a very substantial business, but it did not reach the Kanawha River, a tributary of the Ohio on the western slope of the divide. The Chesapeake and Ohio Canal likewise never reached the Ohio despite the early interest of George Washington and the Erie fever of the 1820s. Instead, it paralleled the Potomac, as the Baltimore and Ohio Railroad would eventually parallel it, from Georgetown to Cumberland, Maryland.

A canal that did "cross" the mountains, the Allegheny Mountains, was built during this period. The Main Canal, some 395 miles long and costing \$10 million to build, connected Pittsburgh with Philadelphia. Promoted by the merchants of Philadelphia who feared the loss of their western trade to New York once the Erie Canal was complete, the Main Line was really a three-mode transportation system. Since the Union Canal was too small, a railroad was built from Philadelphia to the Susquehanna and then along the Juniata River to the Allegheny Mountains near Hollidaysburg. Here the famous Portage Railroad was built.

Cable cars designed to carry canal boats were hauled up one side of the mountain and eased down the other. The canal then continued along the Conemaugh and Allegheny Rivers to Pittsburgh.

The Main Line did considerable business, though it was never a strong competitor of the Erie. It rose 2,200 feet above sea level compared to the Erie's maximum of 650 feet. It had 174 locks as against the Erie's 84. Bottlenecks at the Portage Railroad, the locks, and for transshipment at Columbia presented time consuming and costly delays. But Pennsylvania had canal fever and seemed determined to bring its blessings to every region of the state. By 1842, builders had completed some 772 miles of canal and work continued on another 162 miles. With the state in financial difficulties, very little further building took place (Taylor 1951:43-45).

The third type of major canals, those in the west which would connect the Ohio-Mississippi system with the Great Lakes, were many and varied, although only a few were financially successful. After years of consideration, the Ohio legislature in 1825 authorized a canal-building program which would unite Lake Erie and the Ohio River by two great state-owned canals "and lead to the construction of one of the greatest systems of internal waterways in the country" (Taylor 1951:46). The 308-mile Ohio and Erie Canal, completed in 1833, connected Cleveland on Lake Erie with Portsmouth on the Ohio River. Further west, the Miami and Erie Canal joined Cincinnati on the Ohio first with Dayton in 1832, and then with Toledo on Lake Erie in 1845. Both canals were successful, having been well planned and constructed.

Then, as in New York and Pennsylvania, came the branches and extensions. Some, like the 25-mile Walhonding Canal, had little justification beyond political logrolling. Others were valuable improvements. Among these, the Ohio and Pennsylvania Canal, which connected the Ohio canals with the "Main Line" of the Pennsylvania System, was of great importance. Traffic on the Ohio canals peaked in 1851. There were a number of reasons for this, but perhaps none more important than the competition of railroads. No state built railroads more rapidly in the 1850s than Ohio. With the significant exception of the Miami, most Ohio canals became obsolete and were rapidly abandoned.

In Kentucky, the two and one-half mile Louisville and Portland Canal was easily the most important and profitable. Completed in late 1830, this short canal went around the falls of the Ohio River at Louisville, greatly facilitating river traffic. Indiana, too, caught the canal-building fever, investing in an extensive system of internal improvements. Depression and bankruptcy forced the state to cut back drastically on its plans so that only two major canals would eventually be completed. One,

the 76-mile Whitewater Canal, connected the Ohio River with the National Road. The other, the Wabash and Erie Canal, was far more ambitious. Plagued by problems both in building and in upkeep, this 450-mile canal, the longest in the United States, connecting Toledo, via the Miami and Erie, with Evansville on the Ohio River, traversed virtually the length and width of the state. Although a portion of the canal was kept open until 1872, even this section eventually closed due to railroad competition and neglect.

In Illinois, the Illinois and Michigan Canal, begun in 1836, would connect Lake Michigan at Chicago with the Illinois River and thus with the Mississippi. Expensive, even contributing to the ruin of the state bank in 1842, the canal was completed in 1848. Like the Erie Canal, which inaugurated the canal boom, the Illinois and Michigan Canal helped close out the era on a successful note. It contributed significantly to the rapid growth of Chicago; enlarged and extended many times over, it continues in active use to the present day (Taylor 1951:46-48).

The Decline of the Canal Boom

By 1860, the great canal-building era had come to an end. Some 4,254 miles of artificial waterway had been constructed in the period 1815-1860, with most of it built during the first half of the boom. The immediate causes for the collapse of canal-building are not hard to find. The financial crises of 1837 and 1839 dried up capital. After 1840, the rate of default on state bonds was so alarming that it became impossible for individual states to sell their bonds or to pledge them for loans. By 1844, \$60 million worth of state bonds were in default; credit was difficult to obtain; and, most state internal improvement programs had collapsed or had been severely curtailed (Segal 1961:200-205). By then, construction costs were known to be significantly higher than estimated, and income from revenue was considerably lower than anticipated. Cold reality had lowered the fever for canalbuilding. So did the fact that most of the natural routes for long-distance artificial waterways had been developed.

Yet some new construction began between 1844 and 1860. This included a short canal known as Saint Marys Falls (1855) connecting Lake Superior and Lake Huron; it was destined, as the Sault Ste. Marie, to carry more traffic than any other canal in the world. Considerable sums also were spent on enlargement and extension of existing canals. So even the next wave in the transportation revolution, the railroad, did not account entirely for the decline in construction and use of a mode of transportation which had about reached its limits in the United States of 1860.

The disadvantages of canals also contributed to their demise. If canal transportation was cheap, it also was very slow. Two to four miles per hour under favorable conditions was the best speed obtainable; the average, of course, was less. Locks, low water, floods, and incompatibility between parts of the system caused delays. And most canals were built in regions where ice forced winter closing for several months each year. A number of canals, both publicly and privately owned, suffered from poor business management, a result, oftentimes, of the circumstances under which they were built. Finally, with terrain and water supply constraints restricting east-west construction, canals could not form a real national transportation network (Puth 1982:119; Taylor 1951:54,55).

However, it was the canals, not the railroads, that produced most of the fall in freight rates. Canals provided the first practical means of transporting high-volume, low-value goods in directions dictated by men, rather than natural waterways. They helped establish trade between regions of the country and, by keeping it inexpensive, they increased regional specialization (Puth 1982:118-119). By connecting these regions, "canals initiated a sequence of cumulative impacts that promoted a rapid rate of economic growth" (Goodrich 1961:247). Most canals were valuable, if not profitable; as one writer put it in discussing the Blackstone Canal: "the canal has been more useful to the public, than to the owners" (Taylor 1951:55).

More often than not, the "owner" was the state. Most canals were financed, either directly or indirectly, through public aid. This usually meant direct ownership and operation by state governments: the federal government, by 1860, subscribed only \$3 million to canal companies, with the Chesapeake and Ohio the chief beneficiary. The federal government also had approximately 4,000,000 acres of the public domain to canal projects. Nevertheless, even where private corporations managed canals, they received a great deal of help from the state. States provided most of the funds mainly by borrowing and selling bonds (easily sold during the canal fever of the 1830s), to be paid off from canal revenues and projected increases in tax revenues as canals stimulated economic development (Taylor 1951:49; Puth 1982:119). Governments financed over 73 per cent of the total investment in canals between 1815-1860 (Goodrich 1961:213).

The great period of canal-building was over by the Civil War. Already more money (and land) was being used to develop railroads in the United States. Yet if the heyday was past, the usefulness of canals was not. As pathbreakers and developers, "the canals were the godmothers of the railways" (Clowes 1929:29). After the war, the railroads had center stage. For several decades, canal building, enlargement, improvement, and even maintenance, were

shunted aside. Of the 4,468 miles of canal which had been constructed in the United States, some two-fifths already had been abandoned by 1880. Just after the turn of the century, only some 2,000 miles of canal were in actual operation. Yet the story was not all one of neglect and abandonment. Appropriations in the Rivers and Harbors Acts of the 1870s, 1880s, and 1890s often were spent on deepening harbors, lakes, and rivers which had been joined by canals into a larger and now more usable waterway system (Johnson 1906:331-333).

Twentieth Century Canal and Waterway Development

After years of neglect, the State of New York, in 1903, decided to spend \$100 million in enlarging and improving the Erie, Oswego, and Champlain canals, transforming much of the system into the New York State Barge Canal. By 1906, in Illinois, the United nearly completed the Hennepin Canal and States had canalization of the Illinois River, providing it with locks and a low water channel depth of seven feet. The United States government also was going forward with improvement of navigation on the Mississippi River (Johnson 1906:334, 336). A six-foot channel was authorized in 1907, although it was never fully achieved by the methods then used. Other projects were being put forward and authorized, as well. One waterway proponent suggested in 1906 that the growing population density in the United States, and the increasing development of industries, pointed up the desirability of constructing several canals for the purpose of giving the more important industrial centers the advantage of both rail and water transportation (Johnson 1906:336).

Indeed, the period beginning during the presidency of Theodore Roosevelt and extending to World War II was a time of resurgence of waterway development. Included during this period, of course, was government action during and immediately after World War I in the formation of the Inland Waterways Corporation (1918), with the organization and operation by Congress of the Federal Barge Lines (Hull and Hull 1967:33), and the public works activities of various New Deal agencies aimed at river and harbor improvements.

The responsibility for planning and overseeing execution of most of this activity in the twentieth century fell to the Corps of Engineers. From 1802 to the present, the Corps developed and improved over 25,000 miles of navigable inland waterways. If much of that was done in the more recent period, by World War I their work already had increased significantly: "In 1921 the Corps had 192 harbors and 294 rivers under improvement, as well as 83 other projects, mainly connected with canals" (Merritt 1979:55).

Perhaps the most important proposal planned in the 1920s and executed largely in the 1930s was authorized in a Rivers and Harbors Act signed into law on July 3, 1930. This was the project to create a nine-foot channel in the Mississippi River from Minneapolis, Minnesota, to St. Louis, Missouri. Over the next decade, an "aquatic staircase" was constructed consisting of 27 locks and dams which would insure the utility of this nine-foot channel; supplemented by channelization and canalization of, among other waterways, the Missouri and Illinois Rivers, the Mississippi was opened as never before to river traffic (Merritt 1979:198). Much of this traffic would pass through New Orleans; between 1920 and 1950, the internal water-borne traffic in New Orleans increased more than 1,400 per cent. Overall, by 1950, there were about 1,300 Congressionally authorized projects providing 28,000 miles of improved navigable waterways, 490 locks and dams, and 270 harbors in the United States (Mississippi Valley Association 1950:21).

During the 1950s, major work on the waterways continued. One of the decade's most important achievements was the realization of a project that had been dreamed of since the time of the earliest settlements in Northeastern America: a continuous, navigable, deep waterway from the Atlantic to the Great Lakes. Because of the terrain and the fact that the waterway would extend through both the United States and Canada, many obstacles, both natural and political, stood in its way. Despite this, some of the system already had been constructed. The Welland Canal in Canada, originally opened in 1829 and enlarged by 1932, used eight locks to overcome a 326-foot rise in joining Lake Ontario with Lake Erie. The previously noted Sault Ste. Marie Canal and locks, bypassing rapids on the St. Marys River, connected Lake Michigan with Lake Superior. But much work remained to be done to make the complete system navigable.

In the early 1950s, the United States and Canada reached agreement on building the St. Lawrence Seaway. Work began in 1954 and was completed in 1959. With the opening of the Seaway, oceangoing ships could travel the 2,342 miles of channel through sixteen locks that now joined Duluth, Minnesota, to the Atlantic. The St. Lawrence Seaway made the dream a reality; four-fifths of the world's salt-water fleet now could sail from the Atlantic Ocean to the head of the Great Lakes in the heart of North America.

The Intracoastal Waterway was built to accommodate smaller craft. It consisted of some 2,700 miles of waterways, including canals, segments of rivers, sounds, bays, and open water. Authorized by Congress and executed by the Corps of Engineers, the Intracoastal Waterway was constructed in two parts that would be linked in Florida (Figure 12). It was designed to afford a protected coastal waterway route along the Atlantic and Gulf



THE INTRACOASTAL WATERWAY

LEGEND PRINCIPAL CONNECTING INLAND WATERWAYS

IMPROVED NTRACOASTAL WATERWAY

OPEN BAY WATER

STATUTE WILES

PRINCIPAL MPROVED CONNECTING WATERWAYS

Figure 12. Map of the Intracoastal Waterway System including the Gulf Intracoastal Waterway (from Corps of Engineers 1948:IX).

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coasts of the United States. With the full realization of this project, commercial tows and other light-draft vessels, unsuited for navigating long stretches of the open Atlantic Ocean and Gulf of Mexico, could move safely from Boston, Massachusetts, to the Florida Keys, and from Florida to Brownsville, Texas. From a series of small, scattered projects in 1828 to larger, better coordinated work one hundred years later, the Intracoastal Waterway finally was completed in the latter half of the twentieth century. Connecting, as it does, with many other major rivers and canals, "the Intracoastal Waterway enables small craft and commercial tows to reach many points throughout the eastern and southern seaboards, the midwest, and the Great Lakes area" (U.S. Army Corps of Engineers 1956:i).

In 1966, after a series of Rivers and Harbors Authorization acts, including important laws passed in 1949, 1956, and 1962, the House Committee on Appropriations reported that the "navigations system of harbors and waterways constructed by the Corps of Engineers now carries almost one and one-quarter billion tons of traffic annually..." (House Report 2044 1966). By 1986, this figure had grown even larger. Perhaps now more than ever, canals and improved waterways are a key factor in the "internal improvements" and transportation system of this nation.

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CHAPTER V

THE DEVELOPMENT OF THE INNER HARBOR NAVIGATION CANAL

The Nineteenth Century

The nineteenth century witnessed a cycle of growth, decline, and resurgence in the New Orleans economy. The golden age of steamboating in the first half of the century meant a significant growth in trade for the port of New Orleans. However, the Civil War and the growth of railroads as a competitor to water-borne commerce would combine to depress the economy for several decades. It was not until James B. Eads successfully completed his jetties at South Pass that trade began to prosper again in the Crescent City. The jetties deepened the pass at the mouth of the Mississippi to allow even the largest ocean steamers to reach New Orleans from the Gulf of Mexico. By 1900, the growth of industry, construction of the jetties, the entrance of railroads into the city, increases in exports of grain and imports of coffee, and a general increase in foreign trade since the depression years of 1893-1895 all seemed to presage a promising economic future for the city.

At the turn of the century, however, no single factor was more encouraging than the prospect of a canal through the Isthmus of Panama, "because New Orleans was 600 miles closer to the isthmus than any major Atlantic port" (Kaufman 1929:335). The port was growing at a rate during the late nineteenth and early twentieth centuries that demanded comprehensive planning in order to maximize economic benefits to the community and the state.

Louisiana's General Assembly responded to this need by creating the Board of Commissioners of the Port of New Orleans in 1896. This board, popularly known as the "Dock Board," potentially could play a large role in the development of the Port because the Louisiana Civil Code provided that the shores of all navigable rivers were subject to a servitude for the public or common utility. Subsequent court interpretations of this law would give the Port Commission the right to build public wharves on the bank and batture of the river. However, the Commission could not lease such facilities to private interests, thus retarding industrial development in the Port. To correct this problem, a Constitutional Convention, meeting in 1898, wrote into the Louisiana Constitution a new article permitting riparian land owners to build improvements on their land if they received permission from th appropriate governing authority. The Board of Commissioners of the Port of New Orleans was that authority in the New Orleans area, and as a result, its power was increased even further.

Despite these great strides in providing control and direction for the Port of New Orleans, two significant problems remained. First, industries were loathe to invest in construction in the Port area when the state at any time could expropriate the land under the servitude provision of the Civil Code. Second, the elusive Mississippi-Pontchartrain canal still had not been built. Although it was not initially conceptualized that way, successful prosecution of the latter project also would address the former issue. The eventual decision to build the canal was based on the need for a navigation canal. As the project evolved, it became clear that this canal also could play an important role in industrial development.

Legislation and Funding

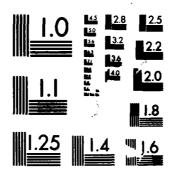
In July, 1914, "after twelve years of propaganda," the state legislature passed Act No. 244 authorizing the Port Commission to build the Industrial Canal (Kendall 1922:627). The Commission Council of New Orleans was charged with determining the site. The Dock Board was given the right to expropriate any property necessary and to issue bonds to pay for the construction. This act was adopted as an amendment to the Constitution in November of that year.

Thomas Ewing Dabney wrote in 1921 that "the canal for which the legislature made provision in 1914 bears about the relation to the one that was finally built as the acorn does to the oak" (Dabney 1921:8). It originally was envisioned as a barge canal. Even that modest conception was pushed aside, however, by the outbreak of World War I. In 1915, the project was revived by a group of businessmen and newspaper editors, spurred by the growing realization of the opportunities offered by the opening of the Panama Canal and by the conviction that, as the New Orleans Item (October 22, 1915) put it, "the lack of that canal has alter proven to have cost the city much in trade and developed industry. The engineering firm of Ford, Bacon, and Davis was return prepare a "Report on the New Orleans Ship Canal and Terminal final report, dated June 30, 1915, had two basis to the second content of the second canal and Terminal final report, dated June 30, 1915, had two basis to the second canal and Terminal final report.

an exposition of the conditions and as and which insure the supremacy and advantage the Port of New Orleans; and, at a real appropriate proposed ship canal and terminal actions (Ford, Bacon, and Davis 141)

The report pointed nut that the had increased between the \$17,490,811.00 to 254, 517,

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for a governmental role in assuring competitive rates so that the river could recapture some of the business lost to the railroads during the last half of the nineteenth century.

This report gave the first clear indication of the importance of the canal as more than just a ship canal. The term "industrial basin" was used throughout the report, marking a new emphasis on recruiting manufacturing to New Orleans. Although the Port was involved in handling ships carrying large amounts of tonnage, New Orleans was primarily a transshipment point, rather than an industrial or manufacturing center or even a market of deposit. The Industrial Canal was now being envisioned as a way to change those circumstances. As the report put it,

the shipping tonnage which it could be assumed would make immediate use of a canal connecting Lake Pontchartrain and the Mississippi River, and used primarily for the coordination of lake and river traffic, is so small compared to the possibilities of this undertaking as an industrial basin as to quite overshadow the former (Ford, Bacon, and Davis 1915:17).

The report then pointed out the advantages of an industrial basin, the foremost being the possibility of private ownership, a possibility which did not exist on the riverfront. Furthermore, the basin could be expanded indefinitely with the addition of lateral canals.

Initial Proposals: Inner Harbor Navigation Canal

The consulting engineers recommended a route that would cost \$2,437,046.00. This route would cut across the Ursuline Convent property described previously, and it was by far the least expensive of those considered. The engineers proposed a barge canal 175 feet wide at the top, 80 feet wide at the bottom, 10 feet deep, and 5.3 miles long. This canal would address not only the question of ownership, but it also would address the question of transportation. Under this plan, a manufacturer could have a waterfront with a canal on one side of the factory and a railroad on the other, providing "complete coordination of rail and water facilities right at his place of business" (Ford, Bacon, and Davis report concluded 1915:26). The that the facts conclusively the possibility of great development at New Orleans as a port and as an industrial and commercia: center" (Ford, Bacon, and Davis 1915:28).

In the following months, newspapers and business leaders urged immediate action. On January 16, 1916, Governor Luther E.

Hall endorsed the project and told a press conference that work would probably begin in three months. It did not begin. In August, the Governor dismissed the Board of Commissioners and appointed a new Board. During the resultant reorganization, the project once again was put on the back burner.

World War I

By 1918, there was a growing need for ships as a result of the pressures of World War I. New Orleans was well located for the production of ships, but the riverfront was not as desirable for ship building factories as would be a fixed-level canal. A group of New Orleans civic leaders met to discuss this situation. They formed the "Shipbuilding Committee," with a membership composed of the mayor, leading bankers and businessmen, and newspaper editors. On February 10, 1918, they proposed plans for an industrial basin to be connected to the Mississippi River by a lock, so that the water level would be fixed and ships could be built on its banks. The basin eventually would be connected to Lake Pontchartrain by a large canal. According to Thomas Dabney (1921:13), the planned lock-sill depth of 16 to 18 feet,

would be sufficient to allow empty ships to enter or leave the canal, but not loaded. The mere building of ships was thus the principal thought, despite the rhetoric on commercial and industrial possibilities.

The Board of Commissioners met on February 15, 1918, and unanimously approved the plan, subject to satisfactory financial arrangements. The Dock Board arranged to issue bonds to pay for the project; the Board of Levee Commissioners of the New Orleans Levee District, and the New Orleans Public Belt Railroad, would back the project financially until it could produce enough revenue to be self-sustaining. On February 15, 1918, the railroad pledged to contribute \$50,000.00 a year in order to obtain a rail monopoly along the canal. The Levee Commissioners, on the same date, pledged \$125,000.00 a year, in return for which the Dock Board would build and maintain levees along the canal. The Levee Commissioners had the power of taxation; the Port Commissioners did not. Thus "the people of the City of New Orleans would pay the cost of the new canal through an indirect tax" (Stiegman 1971a:25). A total of \$3.5 million in bonds was to be issued, and local bankers agreed to purchase another \$1 million if more bond money was needed to complete the project. The bonds would run for forty years and bear five per cent interest. These bonds would provide the mechanis a for paying the costs of construction once the state legislature passed enabling legislation. This arrangement later was confirmed by an amendment to the state constitution.

Physical Requirements of the Proposed Canal

The actual location of the canal was to be determined by the Commission Council of New Orleans, as provided for in Act 244 of 1914. The selection process was shrouded in secrecy to prevent real estate profiteering. The Council decided on a site in the Third Municipal District which was virtually uninhabited. The site chosen for expropriation was 5 1/3 miles long, 2,200 feet wide, and it covered 897 acres. The canal itself was projected to be 18 feet deep, and the lock was to be 70 X 600 feet. Before construction began, the dimensions were altered again. If the canal was to provide space for shipyards, the 18-foot depth was problematic. The ships, when loaded, would draw 27 feet of water. Even more to the point, industries could not be expected to locate their factories on a canal which would only be deep enough to pass empty ships. As a result, a deeper canal was designed. By June 11, 1918, a 25-foot channel had been designed, increasing the projected cost to \$6 million. The Levee District increased its commitment to the project by \$125,000.00 a year.

Construction of the IHNC

The Goethals Company

On March 15, 1918, the George W. Goethals Company, Inc. was retained by the Dock Board as consulting engineers. Goethals had been Chief Engineer in charge of the construction of the Panama Canal from 1907-1914. By 1917, he had retired from the U.S. Army and announced his intention to work as a consulting engineer in a firm that changed its name to take advantage of his fame. However, Goethals quickly was called back to government service because of the war effort. The claims of other historians notwithstanding, Goethals had very little involvement in the design and construction of the Inner Harbor Navigation Canal and Lock in New Orleans. George M. Wells designed the lock, Henry Goldmark did the gates, and Colonel George R. Goethals was the resident engineer. George R. Goethals was George W. Goethals' son. The similarity of names and the fact that both served as colonels in the Army probably are responsible for the confusion about whether the Chief Engineer of the Panama Canal built the Inner Harbor Navigation Canal and Lock. A careful reading of the George W. Goethals papers indicates that he lived in New York throughout the period of construction. His son, on the other hand, lived in New Orleans from 1919 to 1920.

Excavation

Construction of the IHNC lock and canal complex began on June 6, 1918. The canal site presented a variety of problems and challenges to the engineers. The area nearest the river consisted of low, flat, meadowland occupied by a few houses. The middle part of the site,

several miles in extent - was a gray cypress swamp, with five or six hundred trees to the acre, and always awash. The lake end was trembling prairie marsh land subject to tidal overflow and very soft (Dabney 1921:20).

The spectacle of a large group of men throwing up levees by hand must have been an impressive sight. The material dug from the canal's path served as banks for the lock and canal, and prevented the excavated liquid material from running back into the excavation.

The dimension of the turning basin had been expanded to 950 feet by 1,150 feet. Located several hundred feet beyond the lock, it enabled ships to turn in the canal and go back through the lock into the river. It also provided more frontage for industry. The Foundation Company, a shipyard, was so confident in the successful completion of the canal and lock that it began building its plant on the turning basin before the lock was even begun.

In addition to the men building the levees by hand, a dredge was sent to the lake end of the canal to begin excavation. The Mississippi batture could not be breached until the lock was in place, so excavation was limited to the area between the lock and the lake: "the Mississippi is too mighty a giant to risk such liberties" (Dabney 1921:20). The 2000-foot stretch between the river and the lock would be excavated last, when the lock was completed and the new levees were firmly in place. Because the turning basin site was located only a few hundred yards from Bayou Bienvenu (which empties into Lake Borgne), an excavator was sent to open a small channel into the turning basin. This small channel was significant because it enabled the huge 22-inch suction dredges to get into the turning basin and work outward toward both the lake and the lock site.

As though the ground conditions did not present enough problems, construction was further complicated by the Florida Walk drainage system which emptied into Bayou Bienvenu, and by the railway lines that c ossed the canal site. The drainage canal problem was to be addressed by building an inverted siphon which would pass under the canal. Three railroad lines would cross the canal on bridges which had to be built. In addition, railroad tracks were laid to transport the large amount of material needed for construction; roads were built to permit truck access to the

site; the streetcar line was extended so that workers could reach the site. Dabney described the canal site as follows:

Week by week the labor gangs grew, as the men were able to find places in the attacking line of the industrial battle. Great excavators stalked over the land, pulling themselves along by their dippers which bit out chunks of earth as big as a cart when they 'took a-hold'; the smack of pile drivers, the thump of dynamite and the whistle of dredges filled the air. Buildings sprouted like mushrooms; in the meadow, half a mile from the nearest water, the shipyard of the Foundation Company began to take form (Dabney 1915:21).

Completion of the canal was set for January, 1920.

The Dock Board also had begun construction of a commodity warehouse and wharf, built at the juncture of the canal and the river. While not technically part of the canal project, this undertaking was an example of the Board's determination to encourage industrial development on the canal. The federal government decided a short time later that it needed a supply depot and took over the warehouse and wharf project, building a \$13 million terminal. On May 30, 1918, Doullut and Williams Shipbuilding Company announced that it had been awarded the largest shipbuilding contract yet awarded in the South: \$15 million to build eight 9,600 ton ships for the Emergency Fleet Corporation. The canal made it possible to acquire this contract.

The cost of the canal continued to escalate. By mid-1919, George Wells of the Goethals Company had informed the Board that skyrocketing labor and material costs had doubled the anticipated cost of the project. Another \$6 million would be required. Orleans Levee Board once again had to increase its contribution, this time by an additional \$300,000 per year. At this point, and for the final time, the scope of the project was changed again. The Goethals Company engineers raised the question of whether New Orleans really wanted a lock that was almost large enough. foot depth made no sense given the 27-foot draft of most loaded ocean-going vessels. Therefore, the engineers recommended a 30foot depth. These changes were adopted, requiring another \$7.5 million, bringing the total cost of the canal and lock to \$19.5 million. The bonds would be paid back by the annual contributions of the Levee Board (which now totalled \$925,000.00 per year), and ly the Public Belt Railroad (\$50,000.00 per year). At last, the scope and cost of the final project were decided.

Throughout these machinations, excavation of the canal proceeded apace. The excavation ultimately would amount to

between eight and ten million cubic yards; 95 per cent was wet excavation, done by 20 and 22-inch suction dredges. The cost of excavation was below the figure the engineers had anticipated, less than thirty cents a cubic yard. However, it took a substantial infusion of ingenuity to make the process efficient, because of the subsurface conditions that were encountered.

When dredging began, the giant suction dredges encountered huge stumps and buried tree trunks. Even with 1,000 horsepower engines, the dredges could not remove the wood. An employee of the city's sewerage and water department, A. B. Wood, already had designed a centrifugal impeller to handle sewerage containing trash. When W. J. White, superintendent of dredging on the project, learned of this design, he asked Mr. Wood to adapt his design for use on the dredge "Texas." The results were impressive: average excavated yardage increased from 152 to 445 cubic yards per hour. By September, 1919, the entire canal had been dredged except for the last 2,000 feet between the lock and the river.

Drainage

Another innovative feature occasioned by construction of the canal was the inverted siphon built to carry the waters of the Florida Walk drainage canal under the new canal into the Bayou New Orleans has no natural runoff of rain water. Bienvenu. city is like a saucer (Figure 13), with the levees along the river and the lake forming the rim. The levees prevent water from coming into or going out of the city. To address the consequent flooding problem, the city designed and built what has been described as the greatest drainage system in the world. By 1918, there were six pumping stations on the east side of the river; these stations were connected by a series of drainage canals which crisscrossed the Together, the stations had a discharge capacity of 10,000 cubic feet per second: "the seven billion gallons that these pumps can move a day would fill a lake one mile square and thirty-five feet deep" (Dabney 1921:36). Four canals carried the water out of the city; three emptied into Lake Pontchartrain, and the fourth emptied into Bayou Bienvenu. The challenge was to move this water under the new Industrial Canal.

The siphon was designed to take the Florida Walk water down forty feet, and then return it to pass it under the canal at the same level on the other side, where a pumping station would lift it into the bayou. Two cofferdams were built to permit construction of the siphon; as the result, the flow of water from the canal to the bayou was temporarily cut off. The concrete floor of the siphon was laid forty-six feet below the surface. It was divided into four compartments: two storm chambers, 10 by 13 feet each; one normal weather chamber, 4 by 10 feet; and, one public utilities duct

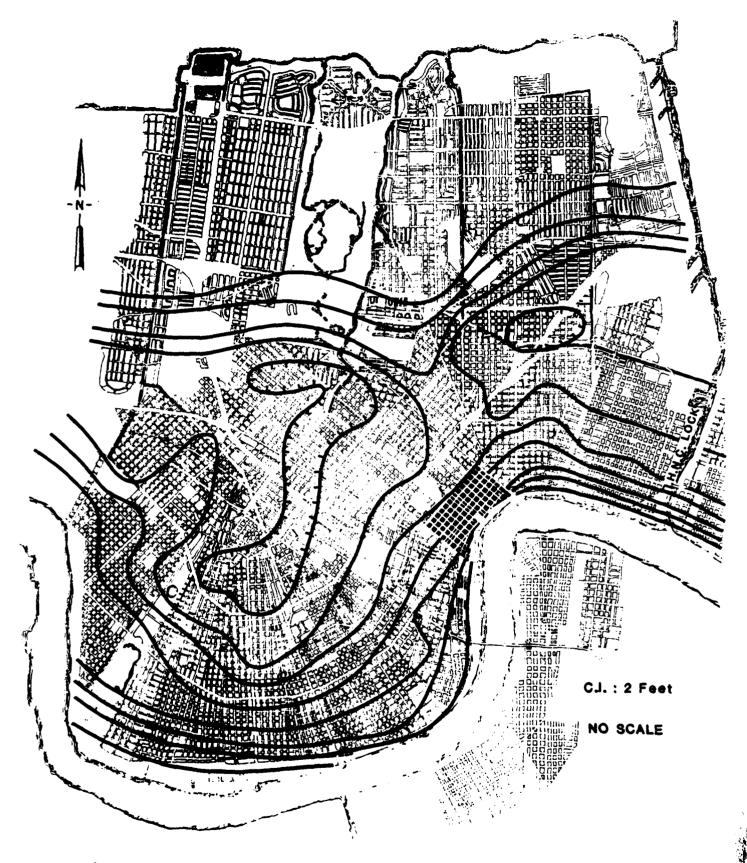


Figure 13. Contour map of the city of New Orleans (Beck 1984:15).

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measuring 6 by 10 feet (inside dimensions). The floor was two feet thick, the roof slightly less. The structure was engineered to withstand a pressure of 2,000 pounds per square foot. The length of the siphon was 378 feet. Eight sluice gates were installed to open and close the chambers. Each gate measured 6 by 10 feet and was operated by hydraulic cylinders. At the time of its construction, the siphon marked the greatest depth that a hole had been excavated in the New Orleans area. The excavation offered a parallel to the problems being met in the construction of the lock, in particular with regard to the quicksand encountered at several levels. The siphon was completed in April, 1920, at a cost of nearly three-quarters of a million dollars. It had a capacity of 2,000 cubic feet of water per second.

Industrial Canal Bridges

Four bascule steel bridges were built across the Industrial Canal to meet the demands of railroad, vehicular, and passenger traffic. Three of the bridges, at Florida Walk for the Southern and Public Belt Railways, at Gentilly for the Louisville and Nashville Railroad, and at the lakefront for the Southern, had superstructures which weighed 1,600,000 pounds each. The fourth bridge at the lock weighed 1,000,000 pounds. They were counterbalanced by concrete blocks weighing 800,000 pounds. The movable section of the bridges was 117 feet out of a total length of 160 feet. Tensile strength of the steel in each bridge was 55,000 to 85,000 pounds per square inch. The bridges included a 30 foot right-of-way for railroad tracks, eleven feet for vehicles and streetcars, and four feet for pedestrians. To open or close the bridges would take a minute and a half. The bridge at the lock had an additional function. The St. Claude bridge,

is inter-locked with the gates and cannot be opened unless the gates are open and ready to receive the ship into the lock chamber. This is a means of preventing accidents, as the mariner will see the great bulk of the bridge when the comparatively inconspicuous lock gates may be unnoticed (Hibernia 1921:6).

Construction of the IHNC Lock

The greatest challenge of all, however, was the construction of the lock, which, according to engineer George R. Goethals, differed "materially from any before constructed" (Goethals 1920:135). He pointed out that:

the lock was not only unique in design, but as far

as our research went at the time, it is the only Lock in the World where peculiar conditions may bring the high level pool at either end of the Lock (Goethals 1920:135).

As noted previously, under normal circumstances, the Mississippi River is higher than Lake Pontchartrain; however, if the river should be at extreme low stage at the same time that strong winds push waters through the Rigolets causing the water to bank up in the canal prism north of the lock, the lake end can be higher than the river end of the lock. This unique situation posed unusual engineering problems. Both the gates and the control machinery had to be designed to cope with the possibility of high water at either end of the lock.

Foundation and Subsurface Conditions

The foundation of the lock required an excavation fifty feet deep because of the great variation that occurred in the level of the river (as much as twenty feet). Dabney has described some of the problems associated with the excavation of the lock foundation:

In solid soil this would be a simple matter. But this ground has been made by the gradual deposit of Mississippi River silt upon what was originally the sandy bed of the ocean and through these deposits run strata of water-bearing sand or quicksand. This flows into the cut and causes the banks to cave and slide into the excavation. Underneath there is a pressure of swamp gas which with the pressure of the collapsing banks squeezes the deeper layers of quicksand upwards creating boils and blowing up the bottom (Dabney 1921:40).

Even doing shallow excavations for sewerage had been enormously complicated by quicksand. The prospect of excavating to a depth of forty-seven feet seemed ominous, indeed. Furthermore, the question arose as to whether the soil that far down would provide enough friction to hold the piles steady and support the weight of the lock and its contents.

Test borings of the usual wash drill type were useless:

The only reliable method was found to be that obtained by driving 10-inch pipe casings, two or three feet at a time, excavating, then repeating the process until the desired depth was reached (Goethals 1920:136).

The first stratum of quicksand began 28 feet below the ground surface and was three feet thick; the second stratum was forty-eight feet below the surface and ten feet thick. Coarser sand extended eleven feet below this (Dabney 1921:42). At 69 feet below surface was a layer of stiff blue clay which devolved into sandy clay to 81 feet below surface where running sand once again was encountered. According to Goethals,

the thickness of this quicksand stratum has never been determined. It can only be said that it extends below elevation -66.5 [Cairo datum] because the cutting edge of the casing was driven to this point without obtaining a seal. It was necessary to prove this stratum was at least ten feet thick for the reason that it was desirable to have the foundation piles bring up in a material other than clay and highly resistive to penetration (Goethals 1920:137).

Excavation of the lock site began in November, 1918. The excavation would be 350 feet wide by 1500 feet long, with a very gradual slope (one-to-four ratio) to the center of the canal to retard crumbling and sliding of the banks. The outside dimensions of the lock to be built in this excavation were 1,020 by 150 feet.

Two hydraulic dredges which had been working on the canal were assigned to begin dredging the lock site. They operated on either side of the center line, making a cut twelve feet deep the entire length of the lock prism. The process was repeated four times until the project depth was achieved.

Systems of Construction: Cofferdams

While dredging was being done, "a wooden sheet pile cofferdam was driven completely surrounding (sic) the lock and about 125 feet from the edge of the bank" (Dabney 1921:42). This cofferdam was designed to cut off the flow from the first stratum of quicksand; otherwise, quicksand would cause disruption in the banks of the excavation. The cofferdam served the additional function of maintaining the water table in the surrounding area, in order to minimize settling of nearby buildings when the water level was lowered in the lock prism. When excavation was well along, a second ring of sheet piling was driven 150 feet inside the original cofferdam to cut off the second stratum of quick sand located only a foot below the planned level of the floor of the lock. The second cofferdam was completed in May, 1919. The land between the south end of the lock and the river had not been disturbed, so the lock prism was enclosed once a temporary cofferdam and earth dike was placed across the north end of the lock.

The next problem was to remove the water from the canal prism without allowing the banks to collapse or the bottom to blow up as a result of the pressure from the quicksand. It was also important to follow procedures which would not damage the integrity of the clay stratum separating the second and third quicksand strata, an eventuality which, in Goethals' opinion, would make construction virtually impossible.

Once the second cofferdam was in place, the dewatering process began. However, after pumping out 6.5 feet of water to - 3.5 feet below Cairo datum, trouble developed:

Cracks appeared along the top of the south and east banks. These rapidly widened and in a short while about one-third of the south bank measured from the southeast corner, were in motion. This was accompanied by violent boils of gas, and water which occurred in various parts of the lock prism. Water was immediately turned back into the lock and as soon as it had risen to -3, the boiling stopped and bank movement ceased. All this occurred in a space of five hours (Goethals 1920:143).

This bank movement consisted of a vertical drop followed by lateral movement toward the center of the lock. The force of the movement was great enough to shear off 300 linear feet of the inner cofferdam and deposit it 30 feet closer to the center of the lock. Although no serious damage was done, it was clear that additional safeguards were required.

After the cofferdam was repaired, a third cofferdam was driven adjacent to the line of outer lock wall construction. By enclosing a relatively small area, it would be possible to install cross-braces (wooden beams ten inches square) to prevent the type of collapse just experienced. The cofferdam this time would be steel; the previous cofferdams were too extensive to permit the use of the more expensive steel pilings which were in short supply anyway because of wartime demands on the steel industry. According to Goethals, "of its type this is one of the largest cofferdams of steel ever driven" (Goethals 1920:146).

A second safeguard took the form of artesian wells. One hundred and thirty (130) ten-inch steel pipes were driven into the third quicksand stratum, which had a static head of 75 feet (Figure 14). These wells were located inside the steel cofferdam:

Gravel was forced down and beyond the bottom of the pipe, forming a bulb which acted as a filter.

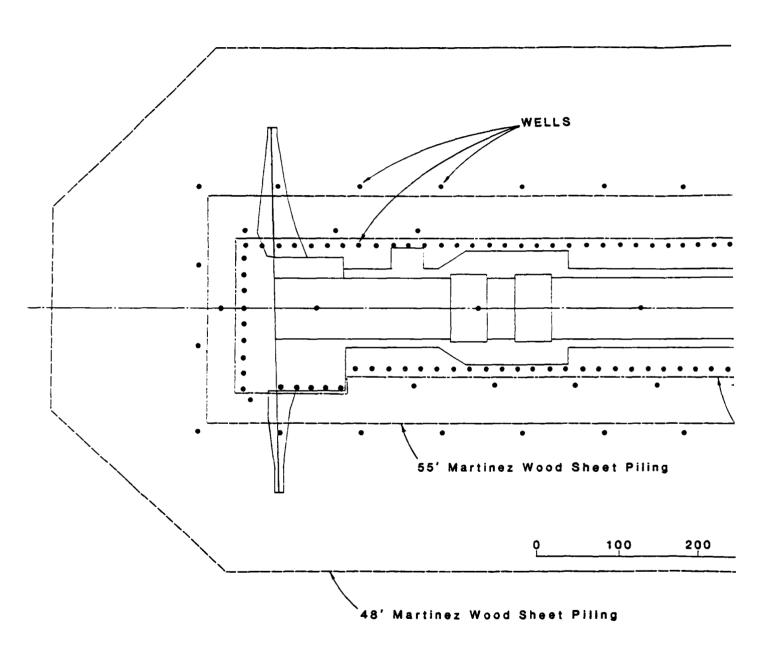
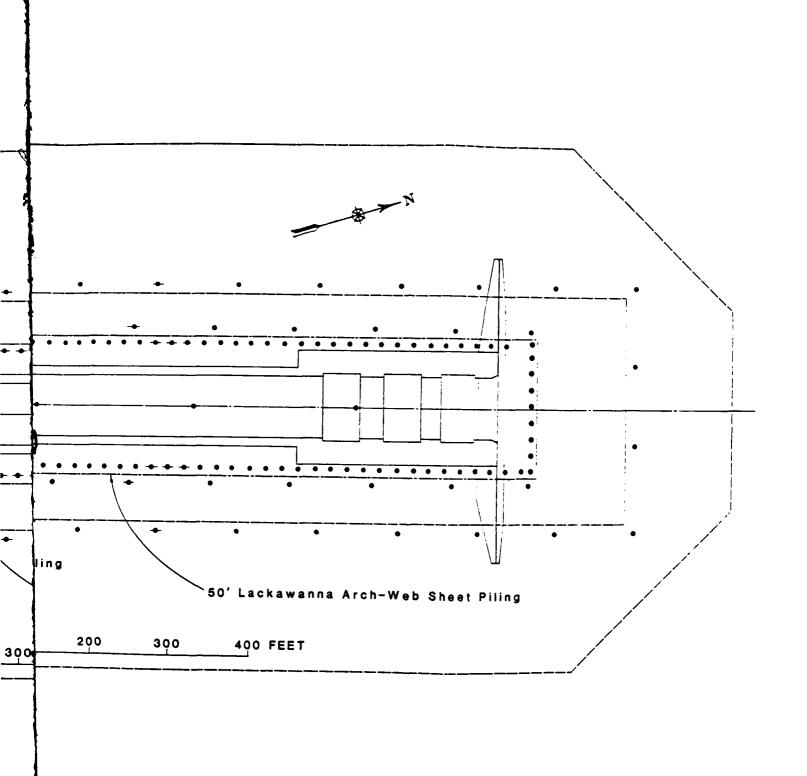


Figure 14. Location of the artesian wells which were dug during the construction of the IHNC lock (Courtesy Board of Commissioners of the Port of New Orleans).



Gravel was also placed in the pipe proper for a distance of twelve feet from the bottom... the result, in all cases, has given a flow of absolutely clear water without any tendency toward clogging of the gravel filter below (Goethals 1920:148).

An additional fifty-six (56) wells were driven to dry out the second stratum of quicksand as much as possible. Half of these wells were driven between the second and third cofferdam. Goethals postulated that the previous breaks and slides had been caused by the flowing of this quicksand. By relieving the pressure and reducing the flow, the wells decreased the possibility of bank movement.

On November 18, 1919, the dewatering process was resumed. Initially, the level was dropped one foot every other day to allow observation of possible effects on the banks. The work was completed on January 4, 1920. The plan worked. This entire process led Goethals to conclude:

It merely goes to furnish another illustration of the fact that the profession of engineering still remains an art, in which imagination and some new application always plays a part, and that the day when this same profession shall be called an exact science is, fortunately or unfortunately, in the future (Goethals 1920:158).

Systems of Construction: Pilings and Lock Chamber

The next task was to drive the 24,000 piles on which the lock would rest. These piles were fifty to sixty feet long. The problems, however, were not over:

Just at the most critical moment, the engineers found themselves fighting the even worse quicksands of local politics.... The whole construction force was threatened with disruption at the worst possible time. By the hardest kind of fighting, the engineers succeeded in keeping their key men from being replaced by irresponsible substitutes, until after the unwatering had been completed and the lock floor poured (Bishop 1930:421).

Although the employees were on the payroll of the Dock Board, the Goethals Company "had been asked to build up the organization for

which we secured many able men from Panama" (Goethals to Bishop, Sept. 28, 1929, Goethals Papers, Library of Congress). The Dock Board, newly appointed by the governor,

proceeded to fire the organization right and left and we had a very unpleasant time trying to save the necks of the employees to whom we were morally responsible for their jobs and to keep irresponsible substitutes from being placed in charge of important features connected with the unwatering program (Goethals to Bishop, Sept. 28, 1929).

At this point, the Head of the Dock Board ordered George W. Goethals to come to New Orleans and appear before the Dock Board. However, the elder Goethals was in the hospital with grippe and could not make the trip. He confided to his son that he was irritated by the manner of the Dock Board's summons, but that he would come to New Orleans after his recovery if necessary. G.W. Goethals later told the New York Rotary Club that:

the best definition I can give the "boards" after my association with them during the war, and with commissions while we were constructing the Canal, is that they are long, narrow, and wooden (Bishop 1930:421-22).

Correspondence between the two Goethals indicated that laying the bottom of the canal was delayed by adverse weather conditions. In March, 1920, the work finally began. The concrete was laid in fifteen-foot sections Lecause only a few braces could be removed at one time. The final product, finished in April, 1921, was a steel and stone monolith weighing 225,000 tons, including gates and machinery (Figure 15). Filled with water, it weighed 350,000 tons. It was 1,020 feet long, 150 feet wide, and 68 feet high. The walls of the lock were 13 feet thick at the bottom, and 2 feet at the top. The 90,000 cubic yards of concrete required 125,000 barrels of cement. Lock construction required six thousand tons of reinforcing steel and two and half million feet of lumber for building forms (Figure 16).

To withstand the pressures of the quicksand, a unique lock design was developed. A brief description was provided by George R. Goethals:

Both walls and floor have... been designed on the principle of an integral whole analogous to the hull of a ship, the walls being nothing more nor less than huge cantilevers transmitting their loads and moments directly to the floor to which

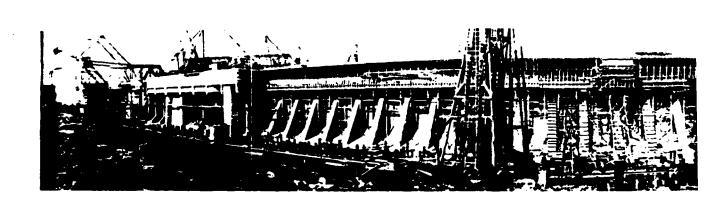
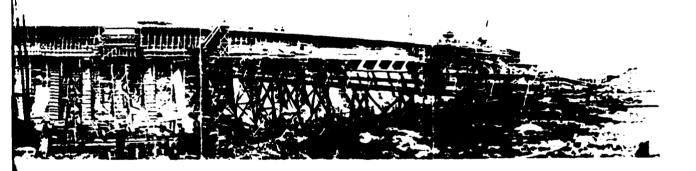


Figure 15. Panoramic view of the IHNC lock during construction in 1921, showing formwork and completed sections of the lock (Courtesy Board of Commissioners of the Port of New Orleans).



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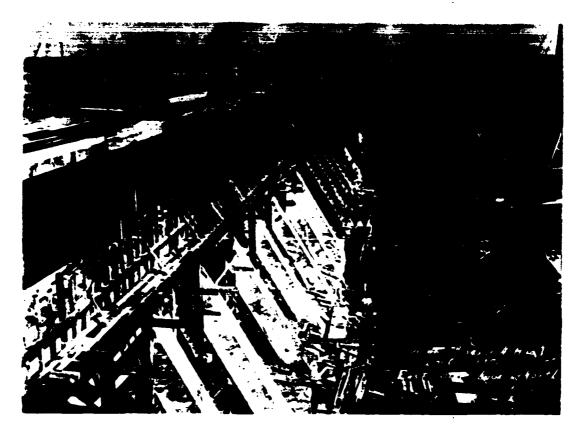




Figure 16. Formwork and steel reinforcing systems used during the construction of the IHNC lock in 1921 (Courtesy Board of Commissioners of the Port of New Orleans).

they (the walls) are securely tied. This gives not only a single unit structure but in addition results in practically a uniform, instead a variable pile loading, thus rendering local settlement practically impossible. To obtain such a relation and condition, the floor of the lock is 9 feet thick in typical sections and 12 feet thick at the gate sections (G.R. Goethals 1920).

IHNC Lock: Mechanical Components

The usable dimensions of the lock were 640 feet long, 75 feet wide, and 30 feet deep (at minimum low water level in the river). The top of the lock stands twenty feet above the ground and six feet above the highest recorded stage of the Mississippi River. design utilizes the natural gravity flow of water to raise and lower the water level in the locks. A series of culverts was built into the base, each culvert measuring 8 by 10 feet (narrowing to 8 \times 8 feet at the opening). They are closed off by eight sluice gates, each operated by a 52 horsepower electric motor. To fill the lock, the sluice gates at the river end would be opened; to empty it, the lake end sluice gates would be opened. It could be filled or emptied in ten minutes. The lock was equipped with five sets of gates, each 4 1/2 feet thick and weighing 200 tons. Four pairs of gates were 55 feet high; one pair was 42 feet high (Figure 17). Each gate fitted flush into the walls when open. The gates were designed by Henry Goldmark, who also designed the gates at the Panama Canal. In the original design, ships entering the lock would be worked through by the use of capstans, two at each end and two in the middle of the lock, each powered by a 52 horsepower electric motor. This approach later was modified.

The control system for the lock was located in a building at the north end of the lock:

In this control house a miniature lock is laid out on the control board, and a direct view of all vessels leaving or entering the lock can be had by the control board operator. If the operator wishes to close a particular set of gates, all he has to do is move the corresponding lever on the control board, or miniature lock. The same holds true of any of the valves, or any of the working parts of the lock. In other words, direct control over any part of the lock is centered in the house, and even the stages of the water at the different points are recorded by miniature gauges in the control house.

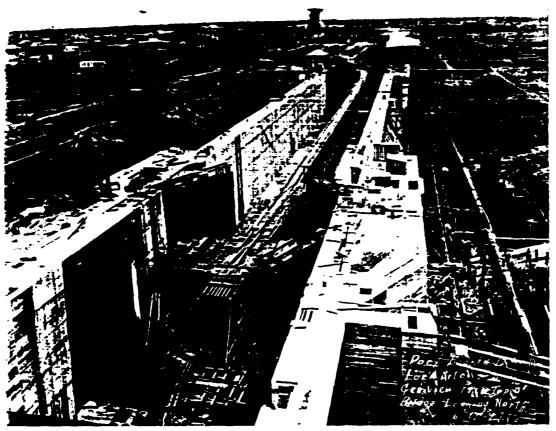


Figure 17. Hanging the miter gates at the IHNC lock in June, 1921 (Courtesy Board of Commissioners of the Port of New Orleans).

Everything is to be electrically controlled (Hibernia 1921:5-6).

This electric control system was identical to the one used on the Panama Canal.

The lock also included an emergency dam, which consisted of eight girders, each 80 feet long, 3 feet wide, and 6 feet high. Each girder weighed 90 tons. They rested on a platform near the river end of the lock, next to a crane with a 300 horsepower motor. If the gates should fail, the emergency dam could be installed in an hour. The crane would lift the girders one at a time and drop them into slots in the lock walls, shutting off the flow of water from the river.

Completion of IHNC Lock Project, and IHNC Development

The lock and canal formally were dedicated on May 2, 1921, an event which coincided with the Mississippi Valley Association's convention in New Orleans. However, the 2,000-foot section between the lock and the river had not yet been excavated. The final cut would not be made until January 29, 1923. Yet the two shipyards located on the canal had been busy throughout the years of canal construction turning out ships:

The Foundation Company, located on the banks of the turning basin, actually began to build ships in the middle of a field, about a mile from the nearest water, so confident did it feel in the ability of New Orleans to convey the project through to a successful conclusion" (Dabney 1921:29).

The Foundation Company launched its first vessel, a 4,200 ton "non-sinkable" steel ship built for the French government, in September, 1919. The S.S. Gauchy went to sea through Bayou Bienvenu. The Doullut and Williams Company launched its first ship in January, 1920. The S.S. New Orleans was a 9,600 ton steel vessel built for the Emergency Fleet Corporation. Since Doullut and Williams was located at the juncture of the canal and Lake Pontchartrain, it was possible for the New Orleans to go to sea via the lake. Doullut and Williams produced seven more ships under its contract; all seven used the lake route to the sea. Similarly, the Gauchy was followed by four additional vessels, all of which used Bayou Bienvenu

Thus, the Inner Harbor Navigation Canal (an appellation which first appears officially in Col. George R. Goethals' report to the Dock Board on October 3, 1919), had attracted millions of dollars

worth of new industry to New Orleans before it was completed. It is not surprising, then, that local business leaders expected much more rapid industrial development than actually occurred.

Connection of the IHNC to the Mississippi River

As noted above, the canal was not connected to the Mississippi River until January 29, 1923. The J.F. Coleman Engineer Co. had become the Dock Board's consulting engineers in 1921, and it immediately was faced with the problem of how the final cut could be made without endangering the lives of the workmen, and without damaging the structural integrity of the lock and of the levees. First, new levees had to be built along either side of the forebay and attached to the river levees. Then the engineers waited for a low stage in the river so that a minimal amount of force would be exerted by the water when it reached the lock gates. On January 29, when the river was only two feet higher than the water in the canal, excavation began. On that date, at 10:30 A.M.,

the wall of dirt that separated the forebay of the canal from the Mississippi crumbled away... and water poured into a gap four feet wide. The dredge boats Dixie and Pelican, operated by the Port Commission, had widened the gap to more than 100 feet before nightfall and the level of the water in the Canal forebay had been brought up to the Mississippi River level (Stiegman 1971a:57f).

Completion of dredging took several days, and the canal finally was opened to river traffic on February 6, 1923 (Figure 18). "On that date the first vessel to enter the canal was the Port Commission's fire tug Sampson with a distinguished party of guests to commemorate the occasion" (Stiegman 1971:53f). After many years of expenditures on the lock and canal, the Port Commission realized its first revenue from the lock on February 9, 1923, when the tugboat Albert A. Thomas, with a tow of a dredge boat and four barges loaded with clam shells, passed through the lock and paid a grand total of \$39.10 in fees.

Regular barge line service through the canal was inaugurated by the Mississippi Warrior Barge Line on February 22, 1923. The self-propelled barge Tuscaloosa was the first. The first oceangoing vessel to traverse the canal on business was the S.S. Commercial Pathfinder on January 20, 1925, almost two years after the canal was completed. It was 400 feet long, had a draft of approximately 30 feet, and carried a load of 800 tons of steel.

The official dedication ceremonies, which did not take place



Figure 18. Cutting through the levee at the Mississippi River, January 29, 1923 (Courtesy Board of Commissioners of the Port of New Orleans).

until May 5, 1923, were attended by great pomp and circumstance. The dignitaries included Governor John M. Parker, Senator Joseph E. Ransdell, and James A. Farrell, president of the United States Steel Corporation. The dignitaries travelled through the lock on the steamers Susquehana and Capital. Bands, cannon salutes, and fireworks complemented the numerous speeches and generally added to the aura of gaiety.

Local business leaders were not prepared to rest on their laurels, however. They viewed the IHNC as one part of a larger plan culminating in a ship canal to the Gulf of Mexico. Even before the canal was completed, they had proposed seven possible routes for such a canal. On April 23, 1921, Col. E. J. Dent, New Orleans District Engineer, rejected them all as not feasible. The project was temporarily shelved, as was a plan to make the IHNC part of the Gulf Intracoastal Waterway. Both projects resurfaced in later years.

IHNC: Jurisdiction and Regulation

The most immediate problem facing the Dock Board was the development of policies to guide the operation of the canal. On April 5, 1921, the Board, under the leadership of President W. O. Hudson, adopted two fundamental principles from which all other policies would flow:

lst. That the development of the Canal will not be at the expense of the riverfront. Wharf development will be pushed on the river to meet the legitimate commercial demands of the Port. No one will be forced on the Canal. That would hurt the port. It was not thought that such forced development would be necessary, and the Canal would be kept open for specialized industry that can best use the coordination of the river, rail and maritime facilities.

2nd. The control of property along the Canal, owned by the Port Commission will not go out of the hands of the Board. There will be longterm leases - up to ninety-nine years, but no outright sale. Furthermore, the private land on the other side of the Port Commission property will not be allowed to be developed at the expense of the state's interests. The frontage on the canal will be developed before there is any extensive construction of lateral basins and slips (Stiegman 1971a:59).

The Board also made it clear that:

it is the Board's policy to make the Canal pay as much as it reasonably can without jeopardizing its development ... its first cost was vastly greater than anyone had estimated, and greater than its immediate income possibilities appear to justify (Hecht 1923:8-9).

Although the Board recognized that it would be unrealistic to expect the canal to be self-supporting in the near future,

in the long run the direct and indirect advantages of the Canal will be so great that the community will be compensated many times for the great expenditures which have been made (Hecht 1923:8-9).

Revenues from the canal would be generated in three categories: (1) in the forms of canal tolls and lock fees on through business between river and lake or bayou, and in the form of mooring fees for vessels lying up in the Canal; (2) in the form of rental for lands owned by the Board on the Canal; and, (3) in the form of charges against laterals for the privilege of connecting with the Canal (Hecht 1923:9). The fees initially were set at 2 1/2 cents per gross ton for the use of the canal, and 5 cents per gross ton for the use of the canal and locks. The rental of the land on the canal required an annual payment of six per cent of the appraised value of the land, with leases available for up to 99 years.

In developing these policies, the Board anticipated that the canal eventually would evolve into an inner harbor. The fixed level of the water would permit the building of permanent wharves of a type not possible on the river. "The result, it is believed, will be that in time a large, exceedingly efficient and economical part of the Port will come to exist in the Canal itself" (Hecht 1923:14). To promote that goal, the Board created the office of the Director of Industrial Development.

The Director, and the Inner Harbor, would struggle for a number of years before any significant success was realized. The first two tenants on the canal were companies dependent on wartime shipbuilding contracts. The end of World War I on November 11, 1918, meant the end of new contracts. The Foundation Company went out of business as soon as its shipbuilding contract was completed. Its lease was cancelled by the Board on May 8, 1922. Doullu. and Williams remained in business by doing ship repair work. The number of industries operating on the canal between the wars was modest: Jones & Laughlin Steel (1923); Lone Star Cement (1925); Gulf, Mobile, and Northern Railroad (1931); U.S. Lighthouse

Service (1934); Lester F. Alexander's ship repair service (1936-37); and, the Louisiana Material Company (1939).

World War II and the Gulf Intracoastal Waterway

The Industrial Canal was neither very industrial nor successful. However, World War II and the development of the Gulf Intracoastal Waterway would change that. World War II meant that shipyards once again would become important tenants on the canal. The Louisiana Shipyards, Inc., (Delta Shipyard) leased four slips that had been dredged by the Gulf, Mobile, and Northern Railroad to procure fill for its fifteen-acre railroad storage yard in 1931. Ten years later, in 1941, the Dock Board's deal with the railroad paid off; the four slips were ideally suited for a shipyard required to begin construction immediately under an emergency contract with the Federal Maritime Commission for Liberty Ships. Shortly thereafter, Higgins Industries, Inc., began driving piles for its new shipyard which would produce navy landing craft. the same month, the Pendleton Shipyards Co., Inc., obtained a lease on the canal to build large ocean-going tugs for the Maritime Commission. Industrial activity continued throughout the war; when the war ended, development along the canal continued, as the canal moved toward the realization of its full potential.

Another event which moved the Industrial Canal closer to full utilization was the designation of the lock and part of the canal as an integral section of the Gulf Intracoastal Waterway. The importance of the GIWW is demonstrated by the fact that the canal continued to grow after World War II: "the biggest growth period was not the 40s, but the 50s. In five years 24 companies have signed on as tenants for canal property" (Times-Picayune, August 21, 1955). Similarly, "the intra-coastal waterway, which flows into the canal is a major factor in the section's growth" (Times-Picayune, May 21, 1955).

The GIWW was a federal project designed to provide a sheltered waterway along the Gulf Coast from Apalachee Bay, Florida, to Brownsville, Texas. Some of the elements of the GIWW were executed before the idea of a GIWW had been conceptualized. The first such project was a Mobile Bay-Mississippi Sound Channel, authorized in 1828; the first improvements to Lake Pontchartrain were made in 1852. The early history of the GIWW was summarized by Carlson (1983:23):

Congress authorized to conduct a survey in 1873 to establish viability of constructing an inland waterway from the Mississippi River to the Rio Grande. The survey was unfavorable, and Congress only approved the construction of a

channel from Galveston to Oyster Bay, Texas, and a waterway from Bayou Plaquemine to Grand Lake, Louisiana. In 1905, Congress authorized the preparation of preliminary plans for the proposed waterway from the Mississippi to the Rio Grande. The results of that study again produced only a segment of the total proposed system - a five foot deep by forty foot wide waterway between Franklin and the Mermentau River, Louisiana. The scope of the project increased in 1909 when a survey for a continuous inland Gulf waterway from St. George Sound, Florida, to the Rio Grande was authorized (Carlson 1983:23).

The Rivers and Harbors Act of 1910 authorized the construction of a number of projects which would become part of the GIWW. By 1925, a continuous waterway existed from the Mississippi River to the Sabine River. The Federal government had purchased three privately built canals to complete the waterway, including the Harvey Canal. The Harvey Canal included a lock, which the government subsequently found inadequate and replaced by 1934.

The Rivers and Harbors Act of 1925 authorized a preliminary examination and survey of the section of the Mobile Bay to New Orleans waterway, "with a view to securing a depth suitable to the economical operation of self-propelled barges" (H.Doc. 341, 71 Cong., 2d sess.:2). This survey projected the entire IHNC as part of the inland waterway system. The River and Harbor Act of 1942 assured the successful completion of the GIWW. It authorized a channel 12 feet deep and 125 feet wide from Apalachee Bay, Florida, to the Mexican border. This Act:

also authorized Federal acquisition and control of the state owned Inner Harbor Navigation Canal and Lock... to insure ultimate control over the maintenance and operation of the entire waterway system and to provide toll free passage along it (Carlson 1983:24).

Equally significant was the provision in the law for construction of a bypass canal. Lester F. Alexander, president of the Dock Board, summarized the situation in a letter to Joseph B. Eastman, Director of the Office of Defense Transportation, on July 2, 1943:

Eastbound traffic after leaving the Industrial Canal, entered Lake Pontchartrain and then through the Rigolets to Mississippi Sound; to my mind, this was an unsafe, uneconomical and in

every way an unsatisfactory channel, therefore, we strongly supported legislation providing for the construction of a by-pass canal leaving the Industrial Canal about 3,000 feet from its entrance to the Mississippi River extending through the marsh to the Mississippi Sound, eliminating seven bridges while only one crossed the proposed canal, and shortened the distance nine miles, thus avoiding an extremely rough lake.

The Dock Board had approached members of Congress as early as 1939 about making the Industrial Canal part of the GIWW. However, the outstanding debt on the canal prevented an outright transfer of ownership. The bonds which paid for construction of the canal and lock were not liquidated until 1960. The bonds also required the Board to operate and maintain the canal and lock. Therefore, General Manager John McKay wrote to District Engineer Captain R. A. Lovett on April 2, 1940, offering to lease the facilities to the government. After considerable pressure from the Office of Defense Transportation, which wanted the lock operating 24 hours a day to expedite petroleum shipments, a lease agreement was finally signed on March 17, 1944. Authorization for the lease had been contained in the River and Harbor Act of 1942, but legal and technical difficulties had prevented an earlier resolution of the issue. Under the terms of the lease, the Government would pay the k Board \$240,000.00 a year, and would operate and maintain that section of the canal from the point at which the GIWW entered the canal (3,000 feet north of Florida Avenue) to the Mississippi River, including the lock, the St. Claude Avenue Bridge, and the Florida Avenue Bridge. Operation was 24 hours a day, and no fees were charged for use of the GIWW portion of the canal and lock. The Dock Board's primary obligation was for major repairs (defined as over \$500 per item).

The GIWW eventually entered the Industrial Canal through the Vickery Canal, a canal born of wartime exigency. Higgins Industries, Inc. was awarded a government contract to build ships at a place called Michoud Station. Although the plant was well along in construction, and ships were being fabricated, there was still no access to the Gulf. Unexpectedly on April 16, 1942, dredging began in the Industrial Canal. Preparations were made on the authority of Brigadier General M. Tyler, Gulf Division Engineer, U.S. Army Engineers, to cut through the canal bank and dredge a canal to the Michoud Shipyard (a distance of seven miles). The Dock Board had not been consulted. Not only did such a cut violate the integrity of the canal bank and levee, but it was done without levees to protect Industrial Canal tenants. Furthermore, this new canal would create miles of canal banks, with access to the Industrial Canal, in the hands of the railroads and other

corporations, a direct contravention of the port's policy of public ownership of harbor frontage.

Board Vice President Pendleton E. Lehde immediately sent a telegram to the U.S. Maritime Commission seeking relief. While protesting that the "Board is eager to extend every available resource and facility to Maritime Commission and Federal Government in successful prosecution of war to final victory," he asked the Commission, "to place control of the banks of this new canal any extensions thereof and adjacent property strips under administration of or ownership of the Dock Board." He also recommended that levees be built before the initial cut was made. After considerable discussion, the Maritime Board decided that the Corps of Engineers should handle these problems. General Tyler and Colonel DeWitt C. Jones (District Engineer) and their staffs met with the Board on April 21st. At that meeting, it was agreed that the Dock Board would acquire the land through which the canal would be excavated in order to control the frontage. The problem of levees was not addressed until 1944, when the New Orleans Levee Board advertised for bids to build levees along the "Vickery Canal," as the Levee Board had designated it. Admiral Vickery was a member of the U.S. Maritime Commission. The name "Vickery Canal" fell into disuse when the canal subsequently became part of the GIWW.

The importance of the GIWW to the war effort is well illustrated by the increase in tonnage on the waterway during the war: in 1934, approximately 2,800,000 tons moved on waterway; in 1944, 24,000,000 tons were logged. Oil (51 per cent) and petroleum products (29 per cent) represented the largest portion of the traffic. In 1948, the Corps of Engineers reported that:

the Waterway afforded a natural and economical mode of transportation for the wide variety of commodities produced or consumed in the Gulf region and, as a result, commerce on the Waterway as a whole had far exceeded the most optimistic expectations (Corps of Engineers 1948:6).

IHMC Lock: Leases and Jurisdiction

Three Supplemental Lease Agreements were signed in 1950, 1951, and 1965. None changed the basic terms of the agreement. The terms were affected, however, by two agreements reached on July 1, 1980: a Supplemental Lease Agreement, and an Agreement to Donate Real Property. In 1976, the Dock Board had requested a renegotiation of the rent to reflect changed economic conditions. After four years of study, the Government agreed to increase the annual rent from \$240,000.00 to \$1.2 million. The corollary

Agreement to Donate Real Property was basically a lease/purchase agreement. Under the terms of this document,

the Port of New Orleans is required to furnish all lands, easements, rights-of-way and dredge spoil disposal areas to the United States of America at no cost, in return for the construction of a replacement lock, and for the provision and maintenance of highway bridges over the waterway... The location of the present lock had been chosen as the location of the replacement lock (Carlson 1983:27).

The transfer of title would occur once rental payments under Supplemental Lease Agreement No. 4 equalled \$11,752,624.00 (fair market value as of the date of the agreement), or if the Government should request land for construction of a new lock as provided in Public Law 455 dated March 29, 1956. In effect,

the United States Government committed to the eventual acquisition of total ownership of the leased facilities. According to the conditions of the agreement, this exchange in ownership would occur in 1990 - the approximate year the lock and its facilities became fully amortized and their physical life expectancy had come to term (Carlson 1983:27).

This agreement would relieve the Dock Board of a significant financial burden and would give the Government complete control over a critical (and deteriorating) link in the GIWW.

The Mississippi River Gulf Outlet

Inclusion of the Inner Harbor Navigation Canal and Lock in the GIWW had assured a high level of use of the facilities, but that was only part of the reason for the Dock Board's construction of the canal and lock in the first place. Even more important to the future of the Port of New Orleans was a ship canal to the sea, and the Industrial Canal was seen by the Board as the first step toward that goal. The Board argued that the passes of the Mississippi were,

too shallow now to meet the full requirements of the Port, and the engineering work of creating and maintaining the present passes and of enlarging them to the greater depths needed is not only immensely expensive but it has no finality (Hecht 1923:19-20). The Board viewed such a canal as an "admirable insurance policy for the Port" (Hecht 1923:19-20).

Even the speakers at the dedication ceremonies on May 5, 1923, sounded a call for a canal to the sea. James A. Farrell, president of United States Steel Corporation, called the proposed canal a necessary and vital development for the Port of New Orleans which would greatly enhance the value of the Inner Harbor. The board agreed and pressed the Government to build such a canal for the next 33 years, culminating in authorization of the Mississippi River - Gulf Outlet by the River and Harbor Act of 1956.

The possibility of such a canal first was given serious consideration by the Federal government in 1943, and then again in 1947. Finally, in January, 1956 the Senate Subcommittee on Flood Control - Rivers and Harbors began the final round of hearings which led to the ultimate approval of the project. The hearings are instructive because they exemplify the arguments advanced in support of the outlet and the extent of support for the project.

Senator Allen Ellender of Louisiana sounded the keynote when he urged the subcommittee to recognize that,

unless the Mississippi River - Gulf Outlet is quickly constructed, the industrial development of the growing Mississippi Valley, the agricultural economy of the area, and the foreign trade which presently flows down the valley and through New Orleans will soon be strangled (U.S. Government Printing Office 1956:3).

Newspapers throughout the Mississippi Valley lent their editorial support to the project. Even five railroads endorsed the MR-GO.

This act also provided for eventual replacement of the IHNC lock. This provision would furnish the only real controversy during the hearings. Senator Roman Hruska of Nebraska guestioned Major General John R. Hardin, president of the Mississippi River Commission, very closely about the lock. Hardin stated that the existing lock would,

for many years to come... serve adequately to let traffic from the tidewater port get through the river because there is only a small percentage of the traffic that will want to go from the newly developed port with its modern facilities over to the riverside (U.S. Government Printing Office 1956:109). Hruska asked why, then, there was a provision in the bill for construction of a new lock if the old one should become obsolete. Hardin replied that it was included only to allow for planning in case of obsolescence. Hruska, however, would not drop the subject:

There is authorization, isn't there, and approval of the construction in the bill? Not only planning, but it is approval of the construction, as I understand it (U.S. Government Printing Office 1956:109).

Hardin admitted that the bill contained that language, but insisted that such a replacement could take place only if economically justified. Once justified, planning could be done without coming back to Congress for authorization; replacement itself would still have to be submitted to Congress. Hruska was adamant that the construction authorization should not be part of the bill, but grudgingly accepted Hardin's representation that it was merely to facilitate planning, when needed. The provision remained in the act.

The MR-GO channel utilized the old Vickery Canal and extended a total length of 76 miles from the IHNC to the Gulf of Mexico. The minimum bottom width authorized was 500 feet, with a depth of 36 feet below Mean Low Gulf. Use of the MR-GO by ocean vessels began during its construction in 1963; the project officially was completed in 1967. Between 1964 and 1981, ship passages increased from 298 to 1478 (396 per cent).

In response to a 1970 Master Plan study of the port by the Bechtel Corporation, the Board proposed that the Tidewater Port area (the banks of the MR-GO) be the site of future major port development. By 1982, over \$500 million had been expended in this area, including the beginning development of the new 7000 acre Almonaster - Michoud Industrial District.

However, even before the MR-GO was approved, the Industrial Canal was nearing capacity with 43 plants located on its banks as of May 21, 1955, and with virtually all remaining sites under negotiation. This growth occurred despite the unusual problems sometimes encountered by the tenants on the canal. Paul Jahncke, Sr. of Jahncke Service, Inc., reported that,

when we moved here in 1948 we really had to brave overgrowth and swamp and even occasional 'earthquakes' when the shell fill-in foundations would cave in under us (Times-Picayune, August 21, 1955).

It took many years, but the canal finally had a significant impact on the port economy. As revenues from the canal increased, expenditures decreased:

In the year 1960, all bonds issued for the construction of the Inner Harbor Navigation Canal, totaling \$19,500,000 were fully paid out. In order to retire that amount of bonds the taxpayers of New Orleans, over a 40-year period, had paid a total of \$47,767,450 in principal and interest (Stiegman 1971a:97).

CHAPTER VI

LOCKS: THE DEVELOPMENT OF THE TECHNOLOGIES

Introduction

This chapter reviews the historical development of the engineering sciences preceding and during the period when the Inner Harbor Navigation Canal lock complex was built. Interpretation of this context is central to evaluation of the lock's significance applying National Register criterion C (36 CFR 60.4), that is, as an exemplar of lock construction technologies during the late nineteenth and early twentieth centuries. This chapter focuses on advancements in the fields of mechanical, structural, and hydraulic engineering that influenced the materials, mechanisms, and building techniques associated with lock construction. These developments derive from the European and American Industrial Revolutions. The origin and development of the various mechanisms designed to operate lock gates, sluices, and emergency mechanisms are reviewed here in diachronic perspective. This discussion will elucidate the review of comparable lock complexes and machinery contained in Chapter VII of this report.

Early Development of Engineering

The first use of lock mechanisms cannot be pinpointed exactly, but it has been suggested that "two-leaf" gate arrangements, i.e., one swinging gate on either side of a canal, were used to control water flow in Babylon nearly three thousand years ago (Hunter 1922). The functions of these gates was to control water levels for irrigation purposes, and to combat floods associated with river cresting. The first navigation locks may have been designed and built during the early renaissance in Italy. In his book Dock and Lock Machinery, W. Henry Hunter wrote:

The honour (of building the first locks) has been claimed for Leonardo da Vinci.... It is certain that towards the end of the fifteenth century Leonardo carried out a scheme of river improvement and canal construction for the Duke of Milan, in which locks were included and usefully employed. But a claim of anticipation of the invention has been advanced on behalf of others, particularly on behalf of certain Dutch engineers (Hunter 1922:10).

The fifteenth, sixteenth, and seventeenth centuries were

characterized by unprecedented growth and reinterpretation within the sciences and arts; they also may be viewed as a period of experimentation and redefinition. During the renaissance, the art of building was influenced by the fledgling science of construction; engineering was slowly becoming an independent branch of architecture. The development of Newtonian physics paved the way for the calculation of complex structural issues. As a result, there was a dynamic change in the approach to construction and its related theories and methodologies. Leonardo Benevelo, in his History of Modern Architecture, stated that:

The science of building, as we understand it today, studies certain practical consequences of the laws of mechanics and was born, one may say, when these laws were formulated for the first time in the seventeenth century; in 1638 Galileo devoted a part of his dialogues to a discussion of the problem of stability. In 1676 Hooke formulated the famous law that bears his name... Mariotte and Bernoulli studied the problem of flexion in 1684.... This occasion saw the elaboration of the concept of the maximum safety load and the invention of mechanisms capable of calculating the resistance of the relevant materials (Benevelo 1977:5-6)

The result of these and other advancements was the fragmentation of what traditionally was defined as architecture. The numerous theoretical tasks involved in construction eventually developed into their own independent sciences. Projects which once had been thought of as ridiculous were becoming theoretically possible. The most significant development during this period was probably the invention of descriptive geometry by Gaspard Monge (1746-1818). This new method of drawing included "various systems of representing a three-dimensional object by means of a two dimensional sheet of paper" (Benevelo 1977:6). In addition, the metric system of measurement was adopted in France in 1801; it became the standard in most of Europe by 1875.

Institutions such as the Ecole des Ingenieurs de Mezieres (1748) and the Ecole Polytechnique (1795) emerged in France and dedicated their curriculums solely to the field of civil engineering. Other schools in Prague, Vienna, and Karlsruhe soon followed as the demand for engineers increased. The combination of new mathematical theories designed to calculate the strengt, of systems and materials with the increased use of descriptive geometry provided a fertile technological environment for the burgeoning Industrial Revolution in Europe and eventually America.

The Industrial Revolution

Rapid population growth during the nineteenth century in Europe helped to spur a tremendous increase in competition among manufacturers and distributors. These changes in the economic system combined with burgeoning theoretical knowledge to produce advances in almost every aspect of research, development, and production. Many manual tasks were superseded by mechanical operations. New materials and theories were commonplace, and a major reinterpretation of man's role in production was underway:

As a result of these and other inventions and improvements, steam driven machinery slowly but surely superseded manual labor, and power driven machines became essential factors in civilized existence (Hunter 1922:21).

The science of engineering was immersed in the development of new materials and the subsequent calculation of the limits of their uses. One of the most important manufacturing advances during the eighteenth and nineteenth centuries was in the improved quality and strength of iron. This new steel was essential in the construction of bridges, sewers, and aqueducts; the impact on architectural and engineering systems of construction was tremendous. New structures emerged which were lightweight, and fireproof; these employed larger spans satisfying the industrial demand for large work spaces. Steel replaced traditional wooden construction members in many industrial applications. In addition, reinforced concrete was invented by a French gardener named M. Joseph Monier in 1867 (Marsh 1904). Twelve years later,

Monier exhibited his system at the Antwerp Exhibition, where it was noticed by Herr G. A. Wayss, who bought the German patents and formed the company of G.P. Wayss and Co., of Berlin and Frankfort, to work the system. Experiments were made, and a thorough study of the subject was undertaken, which proved very clearly the advantages to be gained by this form of construction, and principles were arrived at on which its application should be based (Marsh 1904:3).

With the availability of these new materials and related construction techniques came a new standard of scientific research and specialization within the engineering sciences:

It enabled engineers to tackle the immediate

consequences of the industrial revolution in building and to make progress in constructional theory and practice, thus working towards future experiments (Benevelo 1977:xxxii).

Technological Development of Lock Gate Mechanisms

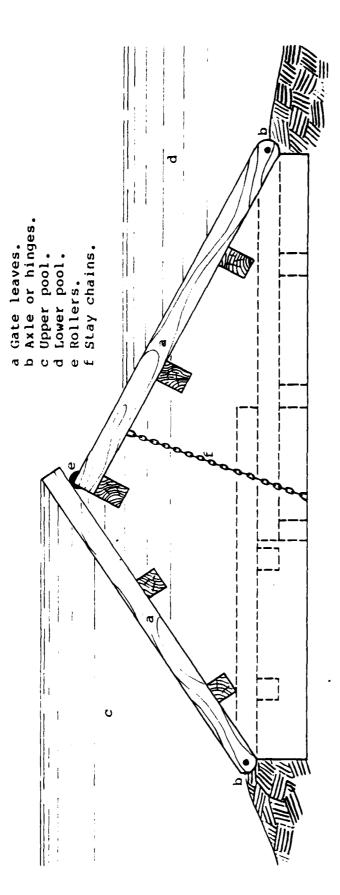
The development of faster and more efficient means of production necessitated both qualitative and quantitative improvements in product distribution. The development of new roads and canals became a priority of manufacturers and politicians alike. These modes of transportation were requisite to the efficient shipment of goods, and they were seen as a necessary means of communication. Roads were made wider; better materials assured more durable surfaces. Canals were dredged to new depths in response to the greater size of cargo vessels. The growing network of European canals for the most part was funded privately by industrialists. The ability to ship large quantities of manufactured products at low costs was imperative to economic growth; the cost for constructing a canal could be absorbed by future profits. One effect of this increase in canals was that the supply of products such as bricks, timber, and iron was made more uniform from region to region.

The construction of so many canals also necessitated the design and execution of numerous associated lock complexes to facilitate safe and rapid navigation. The development of single and double leaf type gate mechanisms is integral to this National Register assessment. Several earlier approaches to lock design also merit review, since they illustrate the intensive experimentation associated with the invention of an optimum solution to the design of locks.

Bear-Trap Gates

The development of the bear-trap type gate in 1818 is attributed to Josiah White, a Philadelphia merchant who was associated with the Lehigh Navigation Company. His pioneering work was undertaken on the Lehigh River; it involved the improvement of river navigation by increasing the depth of the water, and by "producing artificial freshets by means of some kind of movable gate which was to be placed across the river" (Wegmann 1907:344). The result was the invention of the bear-trap gate (Figure 19). Twelve such gates were in place on the Lehigh River by 1819. The bear-trap gate operates in the following fashion (n.b., letter references pertain to Figure 19, and were added to the quotation for clarity):

As originally constructed the gate consists of



Bear-Trap Gate, Davis Island Dam.

Figure 19. Josiah White Bear-trap Gate, circa 1818 (redrawn from Wegmann 1907:Figure 107).

two rectangular leaves [a] of a length equal to the width of the opening in which they are placed. Each of the leaves has at the bottom an axle or hinges [b] which enables it to revolve. When the gate is down the up-stream leaf overlaps the down-stream leaf. The gate is raised by the pressure of the water from the upper pool [c], which is conveyed in a channel controlled by a sluice-gate chamber constructed under the gate. A second channel, also provided with a gate or stop-cock, connects this chamber with the lower pool [d]. When the connection with the upper pool is opened while that with the lower is closed, water from the upper pool fills the chamber under the gate. This causes the downstream leaf to rise, first by flotation and then by the impulse from the flow of the water. rising, the lower leaf raises the upper leaf by its edge sliding under it, the friction being reduced by rollers [e]. The height to which the gate rises is limited either by stay-chains [f] attached to the lower leaf or by a piece of wood nailed on the under side of the upper leaf. lowering the gates, the operation is reversed, the connection with the upper pool being closed while that with the lower pool is opened (Wegmann 1907:345).

Several objectionable features are associated with the bear-trap gate type. These include the necessity to lift a great amount of water during the raising operation. Additionally, the friction between the two gate leaves made it extremely difficult to operate the gate smoothly despite the use of rollers. Gates of this type were prone to damage caused by sudden, jerking stops which tended to break the stay chains. As a result, this gate type soon became obsolete.

The Boule' Gates

Sluice gates, or movable dams, were designed both to contain water and to allow water to pass through them. One of the most widely employed designs of this fashion was developed by M. Boule' in 1874 (Wegmann 1907). Although originally used as the primary lock device in certain canals, this type of gate gradually was adopted as an emergency system when more complex gate operating mechanisms evolved.

The Boule' gate evolved from an earlier gate design which used needles, or planks of wood, to hold back the rush of water; these were placed at the upriver side of the dam. The Boule' Gate

(Figure 20) substituted gates for the needles:

Each of these gates [a] consists of a number of boards, tongued and grooved, and bolted together. They slide vertically between the frames and are maneuvered be a derrick travelling on top of the foot-bridge [b]. In order to limit the transverse strains, to which the gates are subjected, the distance between the frames should not exceed one meter. Thicker boards are used for the lower gates than for the those placed at the top (Wegmann 1907:314-315; a and b refer to Figure 20).

Despite the fact that this dam required a longer setup time, it had distinct advantages over the earlier needle-dam type. Because there were fewer joints, the seal was considerably tighter; the panel assembly also reduced the span of the wooden members. In addition, the Boule' system was less dangerous to operate because of the footbridge on the top. The first use of the Boule' gates was in France; however, by 1876 as many as six such gate complexes were in place on the river Moskowa in Russia (Wegmann 1907). This system eventually was improved with the development of the Camere Curtain Dam (1876-1880) in France. Although this advancement allowed the dam to be operated more easily, movable dams in general may be regarded as a complicated and cumbersome solution to the problem.

Caissons

Caissons, the development of which dates to antiquity, were designed to act as a type of rolling or floating dam which could be placed across the entire length of a canal. The advantage of these gates was their ability to sustain a head of water in either direction. They also could be used as a roadway across the lock entrance capable of carrying automobiles or locotives (Hunter 1922). As was the case with the Boule' system, the use of caissons generally was adopted as an emergency system. They also could be used during maintenance procedures requiring the dewatering (draining) of the locks. Floating caissons were designed and implemented at the Panama Canal for such purposes.

Floating caissons are constructed with chambers that can be filled with either air or water. When there is air in the chamber, the gate is relatively easy to float across the canal. The chambers then are filled with water, and the gate slowly sinks into a grooved section of the lock floor completing the seal. When the gate is to be removed, compressed air is pumped into the chambers and the gate slowly rises so that it can be moved out of the canal.

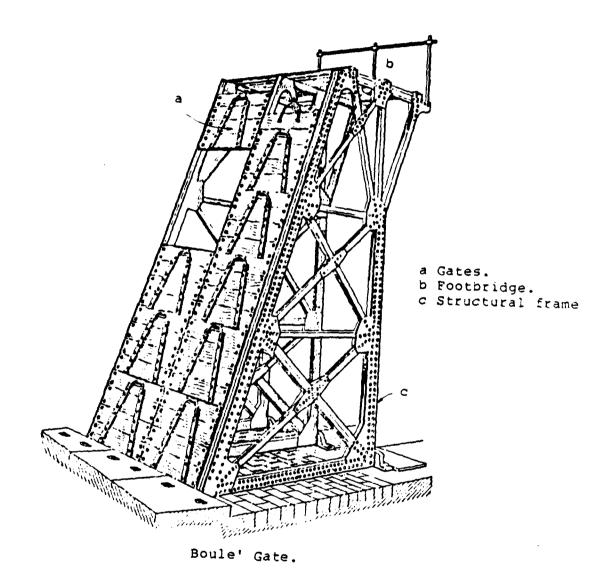


Figure 20. The Loule' Gate or Movable Dam, circa 1874 (after Wegmann 1907:Figure 82).

The other common design is the rolling caisson (Figure 21). The principle is identical to that of the floating caisson with the exception of the means of transportation. The rolling caissons at Zeebrugge in Belgium (Figure 21; a-g illustrate the component parts) operate in the following fashion. The entire gate is moved by an electric winch mechanism which moves the hauling chains (a). The hauling chains are attached to either end of the hauling beam (b), which is connected to the gate itself by means of the draw beam or horn (c). The bottom of the gate is fitted with two sets of rollers (e) at each end; these travel along the roller paths (f). When the gate is in the open position, it is stored in the recess perpendicular to the lock chamber (g). This arrangement has the effect of greatly widening the lock complex.

As noted previously, caissons were used as emergency and control structures during the early twentieth century. Their relevance to the IHNC lock complex is comparative in nature, since no such structure is used at the IHNC complex. It is necessary, however, to understand the popular and successful use of such structures in assessing the significance of the emergency dam mechanism which was used at IHNC. This structure will be described in detail in Chapter VI of this report.

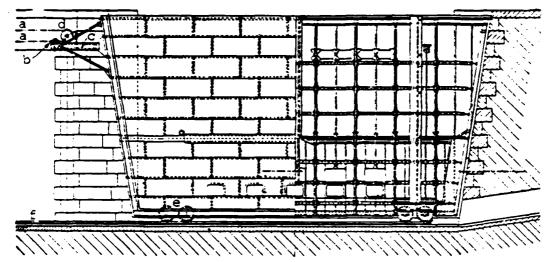
Single and Double Leaf Gates

The development of both single and double leaf gate systems can be traced back to the days of Babylon, three thousand years ago (Hunter 1922:14). Strabon, a Greek geographer born around 64 B.C. described a canal connecting the Nile with the Red Sea. The canal, ending at Arsinoe, was closed by a double door as a precaution against the change of current, and to permit the passsage of ships in both directions (Sarton 1959:422). In more modern times, single leaf gate systems (Figure 22) were very successful navigation solutions in the early, narrow shipping canals of Europe. With the dramatic increase in canal building during the beginning of the 18th century, and the subsequent increase in the size of ships and the amount of goods being moved, new types of lock gates and lock machinery were introduced.

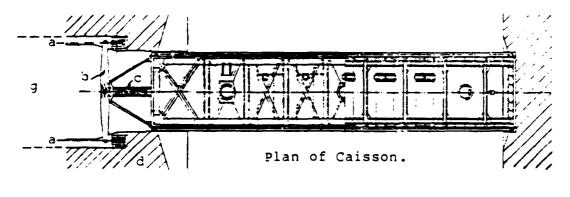
To meet the needs of larger trade, larger boats were demanded and larger lock gates were constructed, though no change in the machinery, therefore, was suggested as yet. The limit of possibility for the single leaf gate was, however, soon reached, and lock gates were constructed which had two leaves instead of one (Hunter 1922:14).

The double leaf gate mechanisms were similar in design to their single leaf predecessors in that they were manually operated, and

- a Endless hauling chains.
- Hauling beam. ь
- Draw beam or horn.
- Return pulleys. đ
- Rollers.
- Roller paths. Recess for caisson.

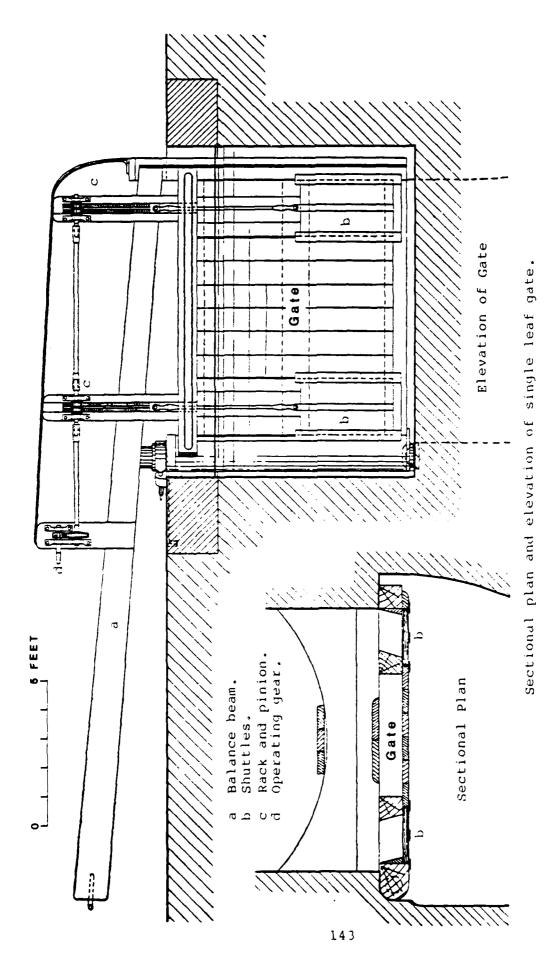


Sectional Elevation of Caisson.



30 FEET

Figure 21. Rolling Caisson Gates at Zeebrugge, Belgium, circa 1904 (redrawn from Hunter 1922:Figure 49).



Manually operated single leaf gate (after Hunter 1922:Figure 1). Figure 22.

they were equipped with shuttles (or sluices) which could be opened or closed to adjust the water level. The annotated Figure 22 can be used as a reference in understanding the operation of the gate: the balance beam (a) is used to pivot the gate into place across the width of the canal. Once the gate is in place, an operator turns the gear (d), which then rotates the rack and pinion mechanism (c). This procedure either raises or lowers the shuttles (b), which allow water to be contained or to flow depending on the direction of lockage. An interesting note is that the use of double leaf gates necessitated, for the first time, full-time employment of lock personnel. The double leaf operation required two people to open and close the gates.

The Quadrant Gate

With the increase in size of lock gates, a new device, the quadrant machine, was developed in the late 18th century to increase the effiency of manual power (see annotated Figure 23). Like the double leaf gate, the operation of this gate type required two operators. The operating gear (e) was set in motion by a hand crank that turned a shaft and thus the pinion (b). The pinion was geared to the quadrant (a) which moved the gate. The entire mechanism retracted (when the gate was open) into a chamber with a guide wheel path (d) bolted onto its floor:

The quadrant and pinion machine was, therefore, worked with sufficient ease by an ordinary gate attendant, who made his initial effort, thus supplying power to overcome the inertia of the stationary gear and of the gate to which the gear was attached, and then easily and without strain kept that gear in motion until the stroke of the opening and closing leaf was completed (Hunter 1922:16).

The problem with this type of mechanism was the need to attach the quadrant at or above the high water level. This forced the placement far above the center of the gate, and therefore exerted extreme pressure at the top of the gate resulting in undesirable torque. Additionally, the recess required for the quadrant while in an open position substantially increased the width of the lock complex. The significance of this operating mechanism is that it introduced the use of spur wheel and pinion gearing to lock gate design.

Hydraulic Mechanisms

The next significant development in gate operating technology was the invention of the winch machine during the late 18th century, which employed the use of wire rope or chains to move

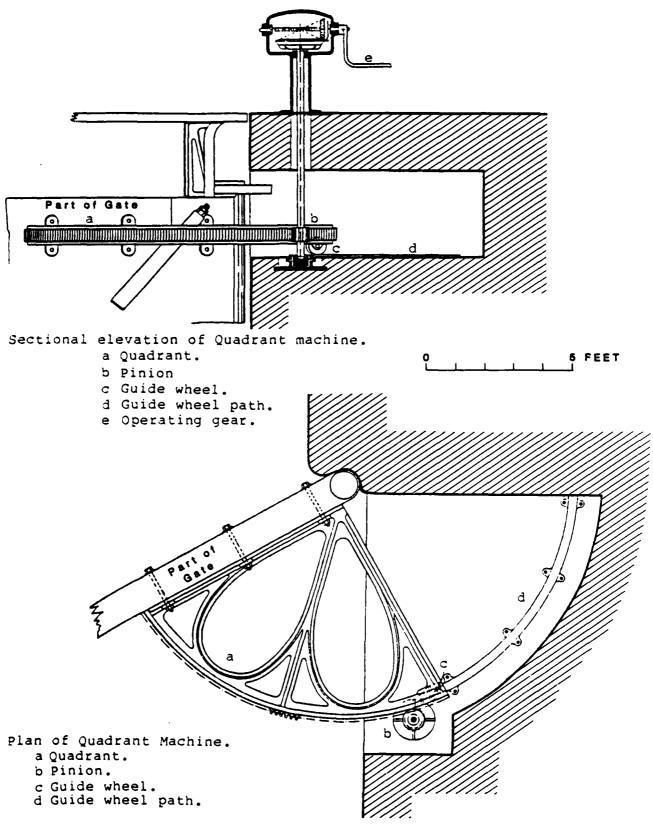


Figure 23. The Quadrant Gate Machine developed by Weaver Navigation, England in the 18th century (after Hunter 1922:Figure 4).

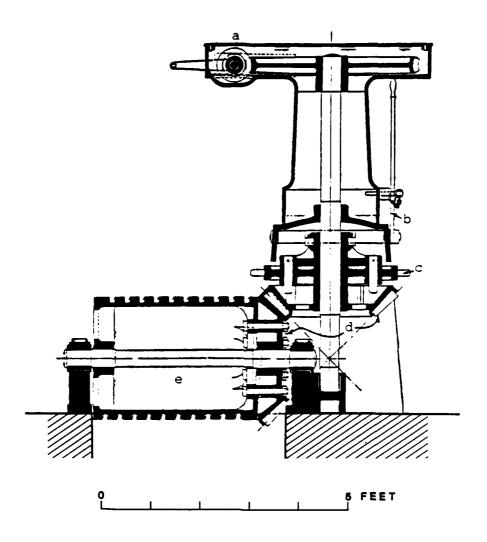
the gates. While this type of gate originally was manually operated, its design lent itself to other modes of power. The problem with this machine type was that it required two machines at each gate leaf: one to open and one to close the gates (Hunter 1922). The winch machines in place at the Grimsby docks in England (see annotated Figure 24) were the first to use the Armstrong hydraulic accumulator, which was designed to help reduce pressure transients in the liquid system. These gates were the first to use hydraulic power; water pressure was derived from a two-hundred foot tower on the site, which slowly pumped water into the barrel chamber (e), and thus eased the operation of the mechanism. Although still manually operated, the Grimsby dock machines represented a departure from traditional methods and paved the way for totally mechanical systems.

Overhead Gate Mechanisms

The hydraulic cylinder soon became the most popular means of movement for lock gate mechanisms in Europe. Two common approaches to the overhead gate system included the hydraulic winch machine and the ram and cylinder mechanism; both used steel rope or chains to move the gates. An interesting example of the overhead chain gate type is the Manchester Shipping Canal exemplar in England, constructed in 1890 (see annotated Figure 25). hydraulic cylinders (a and b) were of the horizontal or ram and cylinder type. Again, two cylinders were required at either side of the lock: one to open and one to close the leaf. The gates were of the mitering type with recesses provided for the open position. The chains were passed through guide sheaves (c), one for the opening operation and one for the closing operation. Two swivel sheaves (d), which fed the chains to the lock walls, were placed near the center of the gate; the closing chain was attached to the opposite wall (e), and the opening chain was attached in a recess covered by the gate when open (f). The gates at Manchester were among the first to be automatic or fully mechanized. In addition, this type of high pressure hydraulic mechanism was found to be very practical for lock operation, and it was used quite extensively during the latter half of the nineteenth century (Hunter 1922). The problems associated with this type of gate mechanism were tied to the increasing size of the vessels which passed through the locks. Eventually, the chains were regarded as constraints, since they interfered with the passage of ships.

The Rack and Pinion System

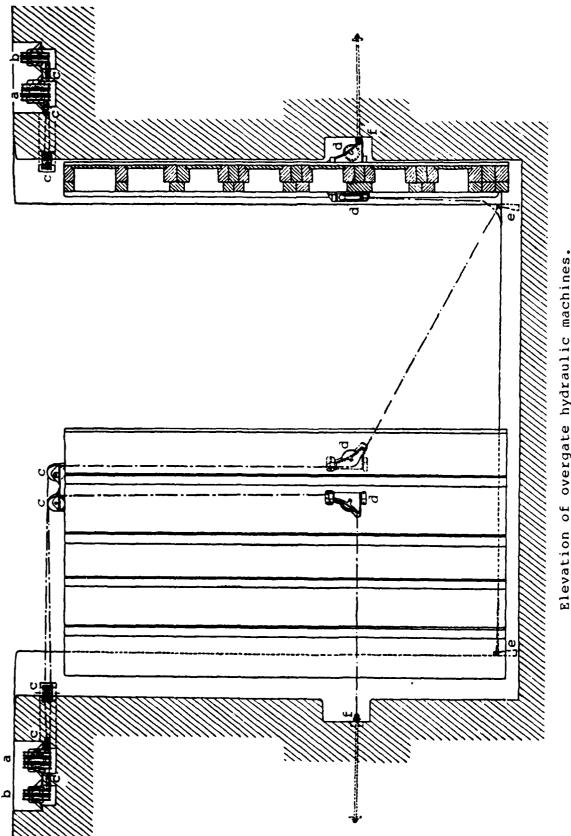
The next significant advance in operating mechanisms was the development of the rack and pinion system (circa 1877), the predecessor of the ring and pinion system used at the Panama Canal and at the Inner Harbor Navigation Canal locks. The significance of the system also lies in the fact that one mechanism facilitated



Cross-section of original winch machine.

- a Hand gear.
- b Attachment for hand gear.
- c Sprocket wheel for chain to hydraulic piston and rod.
- d Mitre gearing.
- e Chain barrel.

Figure 24. Hydraulic Winch Machine, Grimsby Docks, England, circa 1851 (after Hunter 1922:Figure 5).



Elevation of overgate hydraulic machines.

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a Closing cylinder.
b Opening cylinder.
c Guide sheaves.
d Swivel sheaves.
e Attachment for clos

Swivel sheaves. Attachment for closing chain.

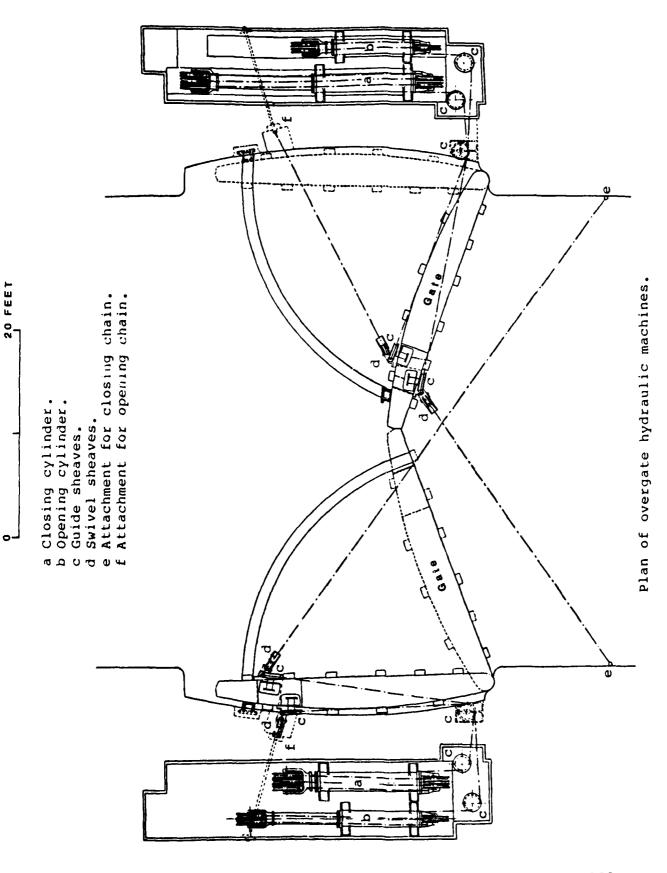


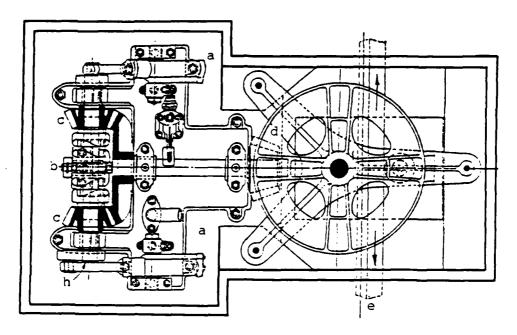
Figure 25. Overhead Gate Mechanism, Manchester Ship Canal, England, circa 1890 (after Hunter 1922:Figure 12).

both gate opening and closing. The machinery at the South Barge Dock, Antwerp, Belgium (see annotated Figure 26) was the first use of this type of device, and was designed by the W.G. Armstrong Company, England. The operation of this mechanism is as follows: the hydraulic engine (a), of the horizontal type, has two oscillating cylinders; these drive a shaft which is keyed to a clutch. On this shaft are two bevel pinions (c), which are engaged by the clutch. The pinions drive a vertical beveled wheel (b) which has the ability to rotate in either direction so that either pinion can set it into motion. This reversing gear is attached to a shaft which has a second beveled gear at its end (d), and which causes the wheel to rotate. This wheel is connected to a shaft that turns and operates the rack (e) and pinion (f) assembly. rack is extended or retracted depending upon whether the gate is to be opened or closed. Again, this system requires a great deal of space to accept the rack when the gates are open; thus, it requires wider locks.

Direct Acting Gate Mechanisms

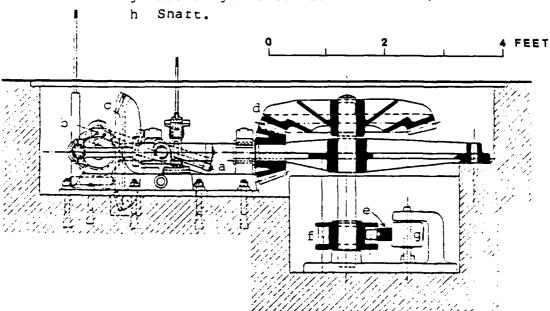
The next line of development in gate operating machinery was a direct result of the increased size of cargo vessels which made the aforementioned systems impractical. Mr. H.M. Brunel, (circa 1890), suggested a form of direct acting gate machinery:

These direct acting machines furnish a further example of mechanical atavism. The fact is that in the course of time, experience showed that concurrent lines of development in gate machines and in the vessels for the sake of which the were evolved had clashed, concurrent lines being (1) those of the cargo steamer which under the stress of the necessity for the conveyance of the maximum amount of cargo at the least possible cost, developed until the midship section of the steamer took a more box shaped form and (2) those of the gate machines in which the necessity for increased dimensions of locks and for the rapid and effective movement of lock gates, had led to the convenient system of connecting the gates with the machines by means of the chains already described, until a point was reached in the dimensions of the steamer at which the box shaped ship and the connecting chains ceased to be compatible with each other, and the special form of chain connection which had been evolved was abandoned, and the original direct acting type of gate machine, which at first appeared as a combination of a balance lever and a bargee, and later in that of a



Plan of hydraulic pinion and rack machine.

- a Hydraulic engine.
- b Reversing gear.
- c Bevelled gear, first motion.
- d Bevelled gear, second motion.
- e Rack and boom.
- f Pinion for rack and boom.
- g Roller guide for rack and boom.



Cross-section of hydraulic pinion and rack machine.

Figure 26. Rack and Pinion Gate Machine, South Barge Dock, Antwerp, Belgium, circa 1877 (after Hunter 1922:Figures 9-10).

quadrant and pinion, was reverted to in the modified form of the hydraulic press and piston... (Hunter 1922:36).

Therefore, the direct acting gate mechanisms were similar in theory to the earlier gate types previously described. Their design was much simpler than the winch or chain machines because of the reduction in the number of parts involved in moving the gate. While the hydraulic chain gates employed pulleys or sheaves attached to the top and middle of the gate, as well as two hydraulic cylinders to open and close each leaf, direct acting machines operated by a single hydraulic cylinder attached to the gate at one point. Although the necessity to place these mechanisms at or near right angles to the lock chamber effectively widened the locks, their efficiency represented a significant reduction in complexity.

A good example of the direct acting approach to gate machinery is the system employed at the Port of Leith in Scotland (see annotated Figure 27). The gate operates in the following fashion: The crocodile beam (a) is attached to a section of iron at the top of the gate (b). The connecting rod (c) has pin joints at either end; one is connected to the crocodile beam at a distance of about one-third of the length of the gate, while the other end is connected to the piston rod (e). The piston rod is kept on track by guides on either side (d). The hydraulic cylinder (f) is a double acting type which serves both to open and to close the gate leaf, thus eliminating the need for two mechanisms. As shown in Figure 27, the orientation of the hydraulic cylinder adds additional width to the locks. It also is considered inconvenient in certain circumstances.

Modes of Power

By the middle of the nineteenth century, the use of hydraulic mechanisms was both widely accepted and implemented. As stated previously, this can be attributed directly to the development of the hydraulic accumulator by Mr. W.G. Armstrong in England in 1851 (Hunter 1922). Hydraulic systems were both efficient and safe; no fire hazard was associated with them (a definite problem with coal fired steam systems). Thus, insurance costs were significantly lower for complexes which employed hydraulic machinery. The operational problems associated with these systems included periodic leakage or blowouts which had the potential to damage valuable machinery and goods. In addition, extremely cold temperatures led to breakdowns associated with freezing:

In some government dockyards in England the difficulty of stoppages from frost led to the substitution of compressed air for the

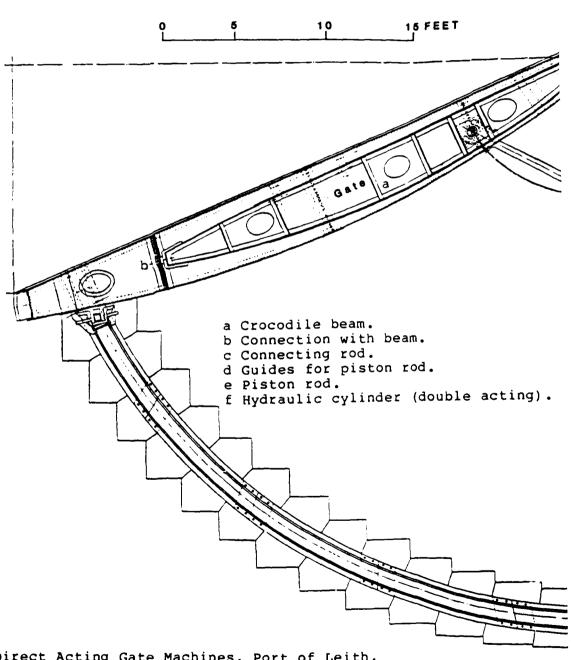
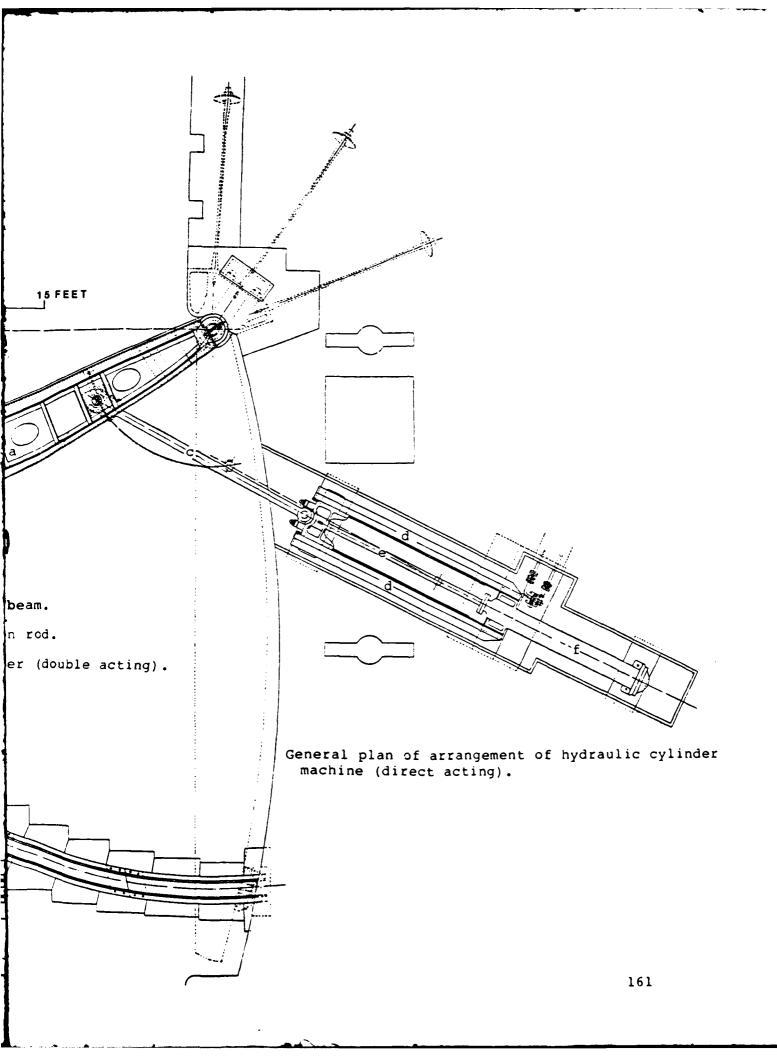


Figure 27. Direct Acting Gate Machines, Port of Leith, Scotland, circa 1900 (after Hunter 1922: Figure 17).



distribution of power, but compressed air is far from being an economical medium; the percentage of the power lost in the useless raising of the temperature of the air which is inseparable from the compression, and the excessive leakage which may take place at joints and valves without being, militate against the usefullness of the medium... (Hunter 1922:186).

Another problem associated with hydraulic mechanisms was that certain locations did not have the perennial supply of water needed to maintain sufficient pressure to operate hydraulic cylinders. As a result of these factors, and of the desire to improve and modify machinery, other modes of power witnessed experimentation after the turn of the twentieth century. The most significant of these was electric motors. Electric motors, developed by Nikola A. Tesla in 1888 and manufactured by George Westinghouse, were found to be a reasonably efficient means of opening and closing gates despite the fact that they required the use of reduction gears. Even though there is a loss of mechanical power associated with reduction gears (a function of friction), they served to increase the mechanical advantage of the electrical motor. the end justifies the means. Electric motors are more compact than their hydraulic counterparts, and they are regarded as a more flexible means of power. The growing availability of electrical power, combined with the previously mentioned deficiencies associated with hydraulic, pneumatic, and coal fired systems, resulted in the adoption of this technology.

The Schildhauer Electric Machine

The Schildhauer Electric Machine first was used at the Panama Canal Gatun Locks, which are nearly identical to those employed at the Inner Harbor Navigation Canal Lock Complex. Interestingly, this gate mechanism represents a combination of several earlier approaches which were described above. Upon examination of Figure 28 it should be understood that this device combined the theories associated with the rack and pinion and direct acting systems. The Schildhauer machine (circa 1904), developed by Edward Schildhauer, an American engineer, employed a ring and pinion mechanism, rather than a rack and pinion; both were activated by a similar spur wheel assembly (c). The advantage of the ring and pinion system is that it did not require the additional space necessary for storing the connecting rod (b), a disadvantage associated with the rack and pinion system. This connecting rod replaced the earlier rack assembly; it pivoted, rather than traveling in a straight line. The connecting rod was attached to the spur wheel by a universal joint (i). The electric motor (f) spun at roughly 400 r.p.m., geared down to acceptable operating speed by both the spur (e) and bevelled gearing (d). The

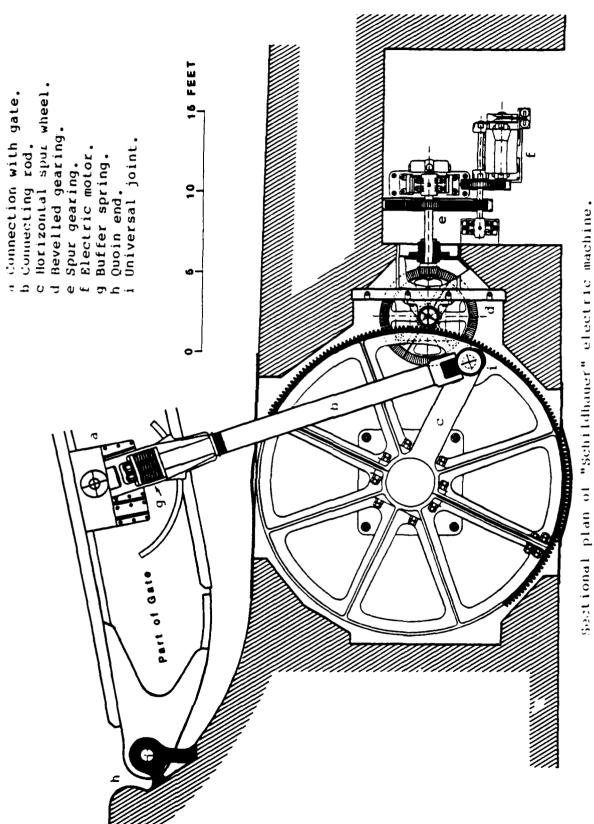


Figure 28. The Schildhauer Electric Gate Machine, Panama Canal, circa 1904 (redrawn from Hunter 1922:Figure 24).

connecting rod (b) was secured to the gate at a distance roughly one-third the length of the gate from the quoin end (h). A buffer spring (g) acted as a shock absorber, and protected the gearing mechanisms from impacts caused by collisions or operational errors. Figure 29 illustrates the movement of the various components during the operation of the gate. The significance of this gate system clearly lies in the simplicity and compactness of the design.

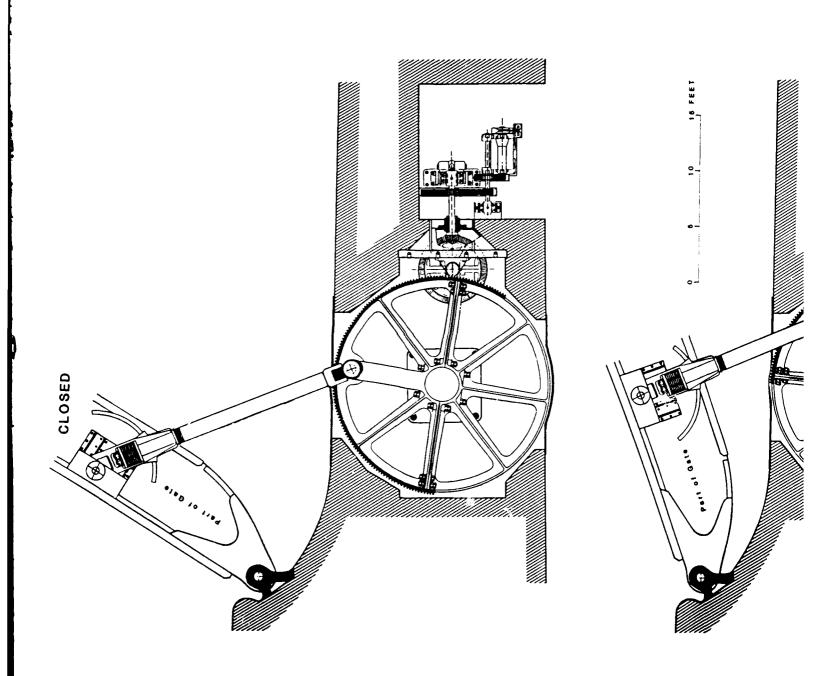
Summary: Gate Operating Machinery

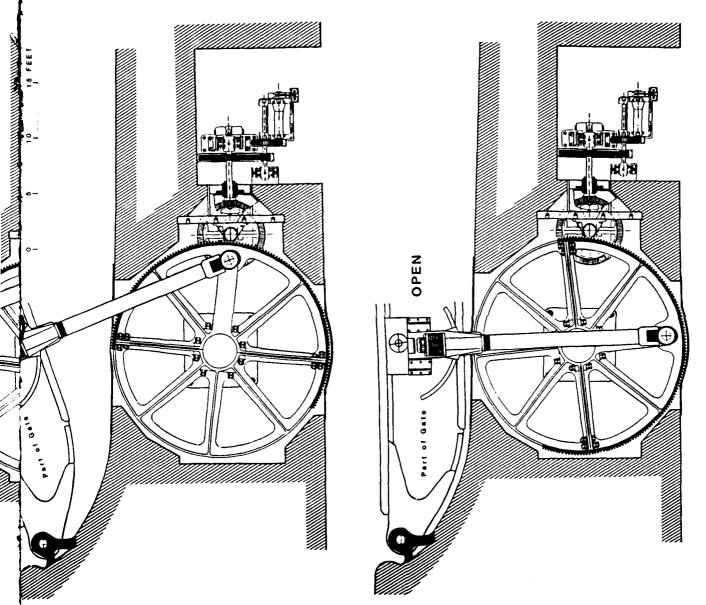
The evolution of gate machinery, as illustrated above and in Table 1, began with relatively simple, direct approaches to the problem of providing a proper seal across a canal. As the availability of related technologies increased, the solutions to this problem grew in complexity. Finally, a point was reached where the gates and their associated mechanisms were at odds with the increasing size of the ships they serviced. After all, the gate had to be a function of vessel size, and not vice versa. The early twentieth century approach to gate machinery design was directed toward streamlining and simplifying. The Schildhauer gate devices used at the Panama Canal were regarded as the most "intensely modern gate machines..." (Hunter 1922:52) of their time. The relatively few number of moving parts reduced the frequency of breakdowns and thus the down time for navigation traffic. In addition, the ring and pinion system required much less operational space. Thus, it effectively reduced the necessary width of lock complexes. This approach to gate machinery design represents a reductive approach to mechanical improvements.

The evolution of gate machines began with simple solutions and gradually evolved into more complex systems such as the winch and chain mechanisms; simplicity gradually returned. The adoption of electricity as the primary mode of power also was responsible for an increased level of reliability. As stated above, the gate machines at the IHNC lock complex are of the same design as those in the Panama Canal. The description of the Panama Canal project in Chapter VII will clarify the other similarities between the two complexes.

TABLE 1. A SUMMARY OF THE HISTORY OF LOCK TECHNOLOGY

TECHNOLOGICAL DEVELOPMENT	DATE OF DEVELOPMENT
Single Leaf Gate	Antiquity
Double Leaf Gate	Antiquity
Descriptive Geometry	18th Century
Quadrant Machine	Late 18th Century
Winch Machine	Late 18th Century
Adoption of the Metric System	1801
Bear-trap Gate	1818
Improvements in Steel Manufacturing	1856
Reinforced Concrete	1867
Boule' Gates	1874
Rack and Pinion Mechanism	1877
Overhead Gate Mechanism	circa 1890
Direct Acting Gate	circa 1890
Schildhauer Electric Machine	1904





Three stages of operation of the Schildhauer gate machines, illustrating the movement of the components (redrawn from Hunter 1922:Figure 24). Figure 29.

CHAPTER VII

A REVIEW OF COMPARABLE LOCK COMPLEXES

Introduction

As noted above, the IHNC lock project was completed in 1921; the Industrial Canal opened to water traffic for the first time in 1923. This chapter examines comparable lock complexes in the United States and Canada that were built between the years 1900 and 1925. This review provides a context for assessing the local, state, and national significance of the IHNC lock. In the following discussion, only the salient design features of each lock complex are addressed in detail. Brief histories of each project, including its location and date of construction, also are provided. As a result, it will be possible to compare the various design methodologies used at the IHNC lock with those of its major contemporaries. Thus, the current National Register status of each of the complexes discussed in this chapter also is reviewed where possible. Finally, several locks in south Louisiana (the Plaquemine, Harvey, and Algiers Locks) are discussed, so that the local significance of the IHNC project may be ascertained accurately.

The assessment of the significance of the IHNC locks as an exemplar of early twentieth century engineering [36 CFR 60.4(c)] requires review of the design and construction of the lock chamber, the type of gate and operating machinery used, the methods and machinery associated with water movement, and the emergency dam mechanism. These components need to be understood in comparative perspective. This detailed examination is necessary because significant advances in the fields of mechanical, structural, and hydraulic engineering often are fleeting due to rapid technological change. The structural significance of such a project also may be tied to special regional constraints on design. This review of comparable lock complexes begins with a description of the most famous and influential project of the period: the Panama Canal.

The Panama Canal

When it officially opened to traffic on August 15, 1914, the Panama Canal project represented the new high watermark of hydraulic, structural, and mechanical engineering. Both the IHNC and the Panama Canal were works associated with the professional life of Major George W. Goethals. Although Mr. Goethals' participation at the IHNC project was minimal, many of the techniques used at the Panama Canal were nearly identical to those

implemented at the IHNC locks. In fact, the success of the Panama Canal system prompted the use of a number of its mechanical design features in other locales. The IHNC project was the first of several "Panama" machine-types in the United States.

One of the most interesting aspects of the Panama Canal project was the monumental scale of construction. The huge lock chambers necessitated the invention of an ingenious network of movable concrete forms. Nevertheless, the theories behind construction were quite straightforward. In the words of George W. Goethals:

Size is a problem in itself; but in what are called the great achievements of the world it has not been by any means the outstanding obstacle. It is no harder to multiply one by one hundred than it is to multiply it by ten. One of the reasons why some men of real ability do not go as far as they should is because they are afraid of the multiplication table! They refuse opportunities, without investigation—because "that is too big for me" (Crowther 1922:16).

The acceptance of concrete as a viable and well-tested building material was requisite to the construction of the Panama Canal. Reinforced concrete was used in:

... a number of... giant structures, such as the Gatun spillway, and various dams, culverts, diversion tunnels, etc; but the most interesting of all will be the mammoth locks. They will be by far the largest and longest concrete structures of the kind in the world, and it is improbable that they ever will be exceeded (Kieffer 1909:44).

The lock at Gatun, Panama was founded on stone that contained small crevices which eventually might transmit hydrostatic pressures from Gatun Lake to the lock floors. This condition necessitated the construction of a floor in the upper lock that could resist these pressures. The thickness of the concrete floor of the lock chamber was twenty feet at the lake end.

The Panama Canal project involved the construction of six lock chambers. At the Atlantic side of the canal, three great locks were built at Gatun. On the Pacific side, three sits of locks were built: one at Pedro Miguel, and two at Miraflores. The three locks at Gatun were arranged in flight (staircase), in order to lift the ships from the tidewater level to that of Gatun Lake, 85 feet above the mean tide. Each lock provided a maximum vertical

lift of 28-1/3 feet, a usable length of 1,000 feet, and a width of 110 feet. Electricity was used as the primary mode of power at Gatun; water turbines at the spillway utilized the 85 foot drop created by the formation of Gatun Lake to generate the power (Bernard 1911). There are five hundred electric motors of various kinds and functions at Gatun, Pedro Miguel, and Miraflores (Scientific American 1914).

The arrangement of the flight of locks at Gatun also required safety mechanisms designed to stop ships from inadvertently carrying away a set of gates:

If a vessel, after crossing the lake, whose level will be 85 feet above the level of the canal at the foot of the lowest lock, were, through some misunderstanding of engine-room signals, to collide even at a very low speed with the gates of the upper lock, they would be crushed in like an eggshell, and a veritable Niagara of water, 90 feet wide and 28 feet deep, would rush into the lock below, carrying the vessel with it at a speed of probably 10 to 15 knots an hour. impact of the water on the gate at the end of the second lock, to say nothing of the momentum of the ship itself, would carry this gate away, and a second 28 foot cataract would be formed, the process being repeated until the ship had swept through the whole flight and the waters of the lake above, covering over 100 square miles of area, were roaring down through the 85-foot cataract on their way to the Atlantic Ocean (Scientific American 1906:78)

To prevent the worst case scenario, sets of fender chains were placed 500 feet above and 230 feet below the upper and lower guard gates (upper and lower chamber entrances). The chain, with links formed from rods three inches in diameter, was placed across the width of the chamber. The chain then passed through large hawse pipes and into pits in the concrete wall (Figure 30). When ships are passing through the lock, the chain is lowered into a groove in the lock floor. When the chain is in its operating position, it forms a barrier to the passage of a runaway ship, gradually stopping it before it hits the gate (Kirkpatrick 1924). These mechanisms are actuated by hydraulic cylinders operated by an electrical pump. There are several documented instances where the use of the fender chains averted a ship/gate collision.

The massive steel gates were erected in pairs as an additional safeguard; thus, runaway ships would have to break through the fender chains as well as two sets of gates to cause a major

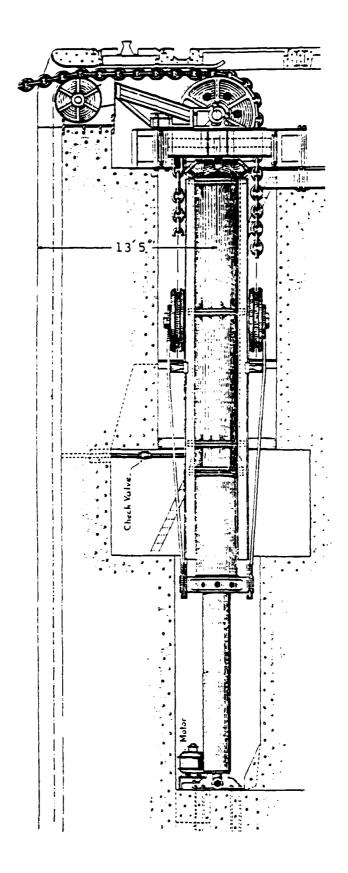


Figure 30. Elevation of chain fender machine at the Panama Canal (after Kirkpatrick 1924:62).

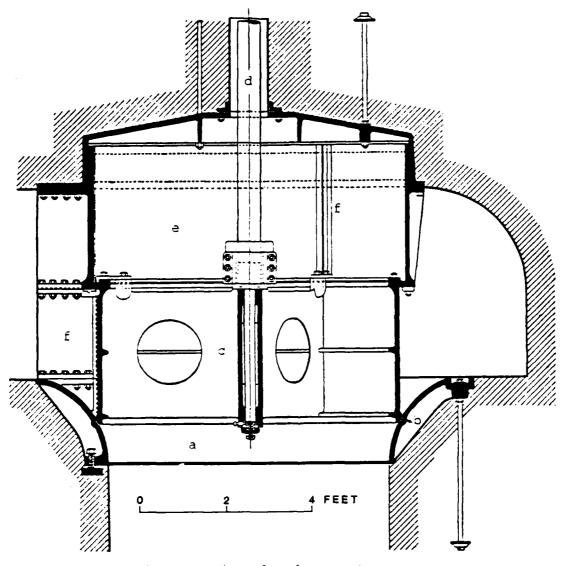
disaster. If all of the abovementioned safety features failed, a huge steel swinging wicket dam could be placed at the Gatun Lake end of the locks. The placement of this dam, similar to the one at the Seattle Canal, would stop the downward flow of water from the lake.

The locks at the Panama Canal are filled and emptied by means of a series of large conduits in the floors; these are connected to larger conduits or circular voids in the side walls of the structure. Each lock has more than one hundred ducts opening into it, increasing the efficiency of lock operation. There are three main culverts, one in the middle wall and one in each side wall. The flow of water is controlled by rising stem valves (sluices) located in the culverts at points opposite each end of each lock; thus, a culvert can can be shut off at any desired point for filling a lock (Scientific American 1914). The central culvert is designed to service the locks on both sides. To control the flow of water, cylindrical valves were placed in the lateral culverts that branch out on either side (Figure 31). A similar gravity feed system is employed at the IHNC lock complex.

The three sets of twin locks in the Panama Canal possess a total of ninety two mitering type gate leaves; these are sheathed on both sides. The lower portion of the gate contains air chambers which reduce the load on the pintle and yoke bearings (hinges). The gates, depending on their location and function, vary in height from 47 feet 4 inches to 82 feet, and in gross weight from 426 to 790 tons (Randolph 1930). When originally designed, these gates were the most massive ever constructed (Goldmark n.d.). The decision to use gates of the mitering type was a function of their low cost and simplicity of design:

None of the moving parts are under water, except the pintle and its bearings, which are well protected and have proved very durable in practice. Its operation requires less time and effort, while its reliability in service has been tested on a much more extended scale and fully proven (Goldmark n.d.:90).

The curved miter leaf was designed to eliminate most of the transverse stress on the leaf, thus reducing the weight of the horizontal frames. The frame of the gate is designed so that the horizontal girders, the vertical bracing, and the intercostals transfer the thrust of the leaves along the quoin (hinged end) and miter posts to the web plates in the horizontals (Goldmark n.d.). As at the IHNC lock complex, greenheart wood is used in Panana for the clapping sill at the lock floor; this sill limits the movement of the gate. The clapping sills at the Panama Canal were the first to use a rubber seal in addition to wood to prevent leakage.



- a Trumpet shaped valve seat.
- b Indent for bearing of cylinder.
- c Working cylinder.
- d Suspension rod.
- e Encasing cylinder or drum.
- f Guides.

Section of closed cylindrical sluice for regulation of water level.

Figure 31. Cylindrical lock sluices at the Panama Canal (after Hunter 1922:Figure 67).

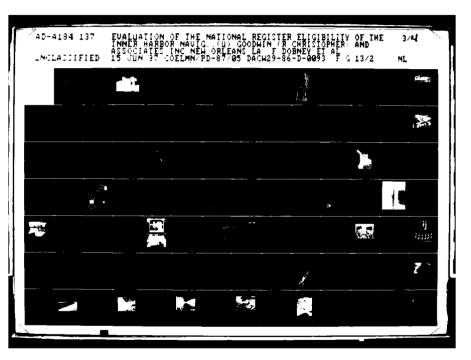
The sheer size of the Panama Canal lock complex could have made its safe operation a nightmare. The control mechanisms designed to operate the various gates and valves are unlike anything used previously (Scientific American 1914). A centralized location for the control panel was necessitated by the distribution of equipment at Gatun over a length of some 4,100 feet. By centralizing operations, both the number of operators and the number of accidents could be reduced. As a solution to the problem,

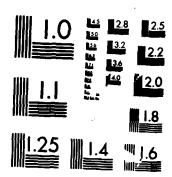
Great electrical control boards [had] therefore been especially invented which are installed at Gatun, Miraflores and Pedro Miguel--control boards which are so ingeniously conceived and constructed that a single man, who need never see the ships which are passing through the canal, opens and closes lock gates weighing many tons and governs the course of thousands and thousands of gallons of water (Scientific American 1914:205).

These control boards were designed by Mr. Edward Schildhauer, the electrical and mechanical engineer of the Isthmian Canal Commission. Mr. Schildhauer also was responsible for the design of the ring and pinion gate mechanisms previously described, which were used at Panama and later at IHNC. These control boards are located within the centrally located control houses; they can best be described as operating miniatures of the lock complex itself (Scientific American 1914). Devices on the control boards replicate the exact position of the gates, as well as the level of water in the various lock chambers (accurate to less than 5/8 of an inch).

The passage of ships through the locks is accomplished by a rather interesting system. Rather than allowing the ships to move through the locks under their own steam, the boats are towed along the length of the locks by traction cars (Sibert 1912). These cars are heavy electric locomotives which take the tow ropes from the vessels and draw them into and through the locks (Bernard 1911).

A final feature of the Panama Canal locks of particular interest is the floating ship type caissons which serve to close the head and tail bays of the lock flights. As previously described, caissons are movable dams which may be placed across the width of a lock chamber or canal. The caissons at Panama are unique in that they not only provide a watertight seal for the chamber but they also contain pumps inside them which are used to drain the water. The ship type caisson derives its no a from the curved ends and hull like design. The stability of the structure is insured by 850 tons of concrete and iron ballast which is place:





MICROCOPY RESOLUTION TEST CHART NATIONAL BUREAU OF STANDARDS-1963-A

near the base of the interior (Goldmark n.d.). The caisson is floated across the chamber until it is in the proper position; then chambers are flooded, and the caisson sinks into place. The arrangement of the interior pumps is such that water may be drawn from either side and discharged through the opposite side. This effectively allows the caisson to be cleaned and maintained on both sides; no special docking is necessary (Goldmark n.d.).

The continuous use of the Panama Canal during its first years of operation was plagued both by World War I and by continuing earth slides at the Culebra Cut (the narrowest section of the canal). The true success of the Panama Canal became apparent shortly after the Armistice. By 1924, less than ten years after the completion of the canal, more tonnage was passing through Panama than through the Suez Canal which opened to traffic in 1869 (Walker 1925). In the opinion of Col. Meriwether L. Walker, Governor of the Panama Canal Zone in 1925,

The special machinery designed for the operation of the locks has met every test, and the numerous safety devices which were adopted have proved so effective that more than 30,000 vessels have been handled without a serious accident... In all other respects, criticism of the present lock canal has been refuted by ten years of successful operation... (Walker 1925:187-88).

The Peterboro Locks, 1903

An interesting approach to lock design was executed by the government of Canada on the Trent Valley Canal system; this canal links Lakes Huron and Ontario. The project involved the construction of twenty miles of new canals along the two hundred mile route of the waterway. Additionally, the highest elevation along the canal is 600 feet above the level of Lake Ontario; this required a series of drops at the eastern end of the canal, the largest being at Peterboro (Fullerton 1903) (Figure 32). These gigantic lift locks:

... consist of two water tight steel boxes, in which vessels will be raised or lowered by hydraulic power from one reach to the other. These pontoons are each 150 feet long, seven feet deep, and thirty eight feet wide, and the pistons on which they are supported are five feet in diameter, of seven inch steel. Only two minutes is required for the raising or lowering of one of these pontoons, which work independently or together, one vessel going up while another goes

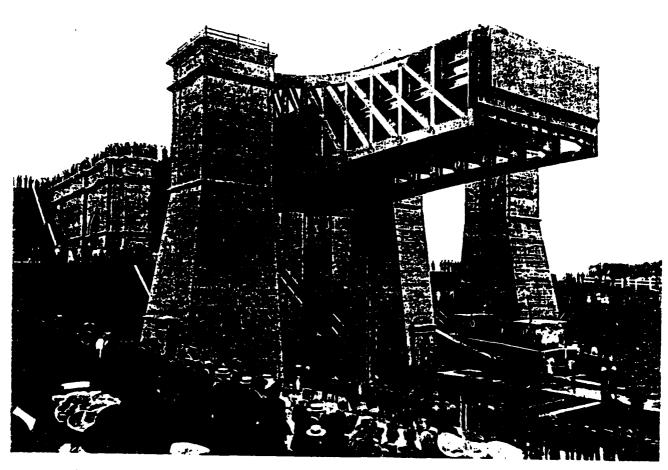


Figure 32. The Peterboro Lift Locks, Trent Valley Canal, Canada (Scientific American 1906:1).

down (Fullerton 1903:260).

The pontoons are raised or lowered to the appropriate water level at which a ship may enter or exit the lock. Once the ship is safely inside the chamber (pontoon), the doors are shut and the raising or lowering process begins. This mitigates the sixty-six foot drop in elevation in the canal.

There is little doubt that the use of reinforced concrete made this project economically feasible. If the same structure were to have been built of stone masonry, the cost would have rendered the project impossible. The project required the pouring of some 26,000 yards of concrete (Scientific American 1918:119). In addition, the solid bedrock (granite) present below the site was sufficient to support the tremendous weight of the lock. It seems to be fairly common practice to seek such subsurface conditions for the construction of lock facilities, since they reduce construction costs associated with excavation and the construction of a foundation.

The significance of the Peterboro lift locks lies in the unique approach to the design. At the time this facility was built, there was only one other such lift lock of this type in the world (Fullerton 1903). The soil conditions of southeastern Louisiana negated the use of such a massive structure at the Inner Harbor Navigation Canal.

Lock and Dam # 53: Ohio River

Lock and Dam \$53 is located about 20 miles northeast of Cairo, Illinois; construction began in 1908. This lock and dam was associated with a massive effort undertaken by the governments of the states of Kentucky and Ohio; the need for these improvements was recognized as early as 1824 by President Madison (Daley 1927). The first lock and dam was completed on the Ohio River in 1885. By 1907, there were more than twenty-six lock and dam complexes along the Ohio:

Each dam constructed added to the length of the navigation periods in the affected parts of the river, and continuous navigation for the upper half of the stream was approaching the predictable (Daley 1927:189).

The dimensions of the lock chamber (110 feet by 600 feet) were adopted as the standard size for all locks constructed on the Ohio River:

The navigable pass is 1,248 feet wide. There

are two bear-trap weirs, each of which is 91 feet wide, and Chanoine and Bebout weir sections. The land wall of the lock is a gravity section 5 feet wide at the bottom... The navigable pass is a concrete floor provided with timber wickets 4 feet wide fastened to horse boxes, which, in turn, are anchored in the concrete.... A bear-trap is an emergency weir, and there must be a difference of level between the upper and the lower pools in order that it may be operated (Suppriger 1928:512-13).

The navigable pass utilizes chanoine wickets for the regulating weir; these are similar to the Boule' system described in the previous section of this chapter. The entire complex is supported by wooden piles with sheet pilings at the perimeter. The use of the wicket system at Lock and Dam \$53 is a good indication of the popularity of this type of emergency mechanism. The emergency dam system at the IHNC lock facility represents a radical departure from this traditional system of canal closure; the significance of this mechanism will be discussed in detail in the following chapter.

St. Marys Falls Locks

The St. Marys River or ship canal is approximately 75 miles long; it connects Lake Superior and Lake Huron. Both American and Canadian canals have been constructed in this area since the late eighteenth century; the first locks were built in 1798 (Dillon 1931). Subsequent lock projects included The Weitzel Lock (1882), the Poe Lock (1896), the Davis Lock (1914), the Sabin Lock (1919), and the MacArthur Lock (1942). In 1984, a study was undertaken by the Detroit District, Corps of Engineers, to assess the impacts involved in the construction of a new lock. Their planned project would involve the demolition of the Davis and Sabin Locks, a lock complex located fourteen miles below the head of the St. Marys River at the falls near Sault Ste. Marie, Michigan.

According to Dillon (1931:205):

In 1837, the State Legislature of Michigan passed an act authorizing the construction of a ship canal around the Falls of St. Marys. Twenty-five thousand dollars was appropriated to be applied to the construction of the canal (Dillon 1931:205).

The project finally was undertaken on the American side of the canal between 1853 and 1855; the State Canal was built during that

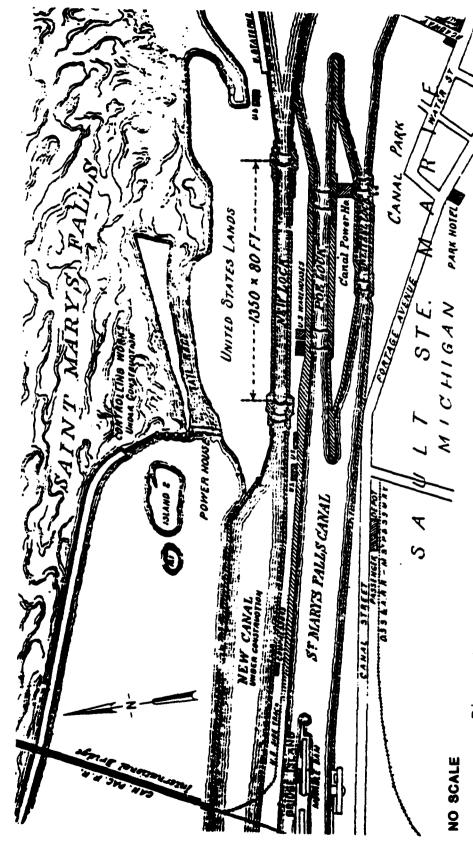
period. The construction of the Poe Locks (Figure 33) between 1887 and 1895 required the destruction of the original lock facility; when constructed, the Poe Locks were the largest in the world. The length of the lock is 800 feet; the width is 100 feet. A third project, the Davis Lock, was completed in 1914 and had a usable length of 1,350 feet and a width of 80 feet. The Fourth Lock (Sabin) was finished in 1919 and possesses the same dimensions as the Davis Lock. The Poe, Davis, and Sabin locks are operated by means of electric power. The entire complex at Sault Ste. Marie is commonly referred to as the "Soo Locks." Despite a relatively short navigation season because of the sub-freezing conditions,

... the tonnage passing through the "Soo Locks" is greater than the combined tonnage through the locks of the great canals of Panama, Suez, Kiel, and Manchester, which are open during the entire year (Dillon 1931:207).

The construction of these locks was aided by the presence of firm bedrock (Potsdam sandstone) below the site; the floor of the locks was laid on rock throughout (C.O.E., Detroit District 1984).

Of all the locks constructed at Sault Ste. Marie. the Davis and Sabin Locks are the only two which were constructed within the same time period as the IHNC complex. The gates used at the Davis and Sabin Locks are of the mitering type, actuated by electric motors. The great length of these locks is a direct function of the volume of shipping at the site. The significance of this site as a National Register Property is linked to this shipping, rather than to the historic lock facilities:

Although it is clear that replacement of the Sabin and Davis locks would result in an alteration of a National Register listed property, the change would have minimal impact on the character or the public's perception of the site. The history of the St. Marys Falls Canal is one of continual modification to meet the needs of navigation. The proposed new lock is simply a continuation of this process which reflects the importance of the site. Because the Sabin and Davis Locks, and the proposed new lock, are removed from public access areas, the modifications proposed should not result in any loss of educational opportunity or enjoyment to the public (C.O.E., Detroit District 1984: A-35-36).



Arrangement of locks at St. Marys Falls, Sault Ste. Marie, Michigan (Mills 1911:546). The new lock shown under construction is the Davis Lock. Figure 33.

The Washington Ship Canal and Locks, 1915

The Government, or Lake Washington, Canal was completed in 1915. It provides a navigable link between Puget Sound and Lake Washington; the canal and associated lock complex are included on the National Register of Historic Places as an historic district. The construction of the canal and locks was funded by the United States Government. At the time of construction, so much attention was directed towards the Panama Canal project at Gatun that the outstanding work in Washington largely was ignored (Scientific American 1914:cx):

The large lock is 80 feet wide and 825 feet long between upper and lower service gates; it is divided into chambers 375 and 450 feet long, by an intermediate gate. Vessels up to 36 feet draft can pass through the large lock (Sargent 1920:325).

In addition to the large lock, a smaller lock was constructed at the site to handle smaller barge traffic; this reduced the operational cost of the complex significantly.

The foundation of the Washington lock was constructed of concrete poured directly upon a clay sub-stratum. Within the larger chamber, five sets of gates were built. These gates are of the mitering type; one has a jaw which accepts a post on the other gate when they swing together, producing a good seal. The gates are double sheathed to form an air chamber which increases the buoyancy of the gate and thus eases movement and simplifies maintenance (Sargent 1920). The gates are operated by electric motors; they work in the following manner:

The gates are actuated by two cables attached near the outer edge of each leaf, the other end of the cables being attached to the spiral drum on the gate-operating machine. The drum spiral is so proportioned as to take up the slack due to change in cable lengths as the gate swings through its arc of revolution. The life of the steel cables used in the operation of the gates is from six months to one year (Sargent 1920:326).

Obviously, the relatively short life of the cables represents an operational problem, because their replacement requires the temporary closing of the lock and employment of a diver to replace the cables; it is unclear why direct acting gate machines, such as those used at Panama and at the IHNC, were not employed here.

One interesting feature associated with the Seattle Canal

Locks is the emergency dam mechanism designed to stop the flow of water in the case of an accident (Figure 34). Although designed and implemented at the same time as the IHNC project, the approach at the Seattle Canal was somewhat different:

The structure for the large lock consists of two removable bridges which span the channel when in use, six wicket girders which form the framework of the dam, twenty-four wickets which complete the dam, and a stiff-leg derrick with the necessary operating machinery for handling the various parts (Sargent 1925:396).

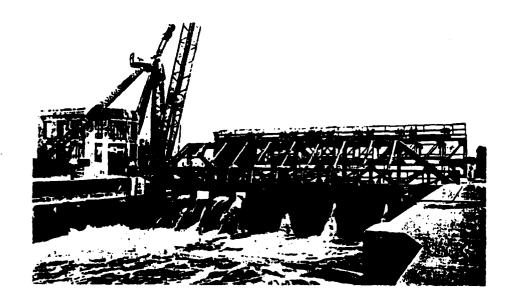
Four hours were required to complete the erection of the dam. The dam and operating machinery were designed by Mr. Arthur Sargent and Mr. C.A.D. Young, under direction of Colonels J.B. Cavanaugh and E.H. Schultz of the Army Corps of Engineers (Sargent 1925).

The Keokuk Lock and Dam Complex

The Keokuk Lock and Dam complex, located at the foot of the Des Moines Rapids in Iowa, was opened to water traffic on June 12, 1915. It presently is listed on the National Register of Historic Places. This lock complex was designed as an improvement to the original facility established in conjunction with the Des Moines Rapids Canal project. In addition, a dam and power plant was constructed at the site. The construction of the large locks was facilitated by the presence of an excellent foundation of bedrock (Meigs 1920). Keokuk was regarded as one of the most innovative and successful projects of the day; in the words of M. Meigs, United States Civil Engineer:

Both the lock and dry dock, and especially the gate mechanism, are built on bold and original lines, and after operating them six seasons it is possible to form a conclusion as to the value of the new forms of gates and appurtenances, hitherto untried, so far as the writer knows (Meigs 1920:192).

At the upper end of the lock, both gates and a railway bridge were required. As a solution, a floating caisson type gate was designed to serve both gate and bridge functions. This gate was constructed so that it was interchangeable with both the guard gate and the dry dock gate to allow easy repair work; these gates were sheathed on only the downstream side. As previously described, the floating/submersible caisson type dam or gate contains air chambers which, when empty, provide sufficient buoyancy to float the gate across the lock chamber. When in place, the five chambers



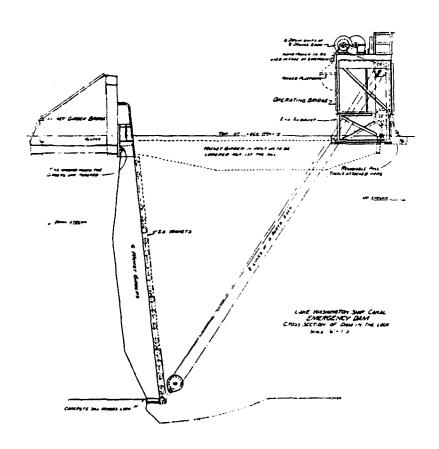


Figure 34. Emergency dam at the Seattle Canal Locks (Sargent 1925:Figures 2-3).

in the Keokuk gates are filled with water and the gate sinks into place. Interestingly, the tanks on these gates are gravitating tanks; they are open at the bottom. The air percolates up from four pipes in the lock floor and fills the chambers. As soon as enough air has escaped into the three tanks, the gate begins to float (Meigs 1920):

The gate operates smoothly and the lock men like it better than mitering gates, to which they were long accustomed. They have learned to give it excess air as it nears the bottom and thus settle gently on its seat. Likewise, they have learned with little trouble to raise it smoothly until it touches the cushioned stops without shock. In short, it operates perfectly and more cannot be said (Meigs 1920:194).

In addition to the floating/submersible gates used at Keokuk, mitering gates also were employed. These gates are curved, rather than straight leaves; when closed, they form a half circle. Other than their curved form, the gates at Keokuk are very similar to the double sheathed gates at the Panama Canal. They also have air chambers to increase buoyancy and decrease wear on the hinges. In addition, the gates at Keokuk are moved by the same bullwheel and strut (ring and pinion) mechanism used at Panama and at the IHNC. However, the primary mode of power at Keokuk is pneumatic rather than electric.

The methods in which the locks at Keokuk are filled and emptied are nearly identical to those employed by the builders of the Panama Canal. A large culvert was placed beneath the east wall of the lock chamber to feed 56 three-foot openings in the lock floor. The valves are on one side of the lock chamber, instead of on two sides as at case at the Panama Canal. The regulating valves are identical to the cylindrical valves used at the Panama Canal; they are made of semi-steel, which is not as strong as steel but allows for the construction of thicker parts reducing the incidence of cracking. These valves were specified by the Board of Engineers, U.S.A. (Meigs 1920). It seems that the project in Panama set many standards of design that later were adopted as government policy. This may further explain similarities between the IHNC and Panama Canal projects.

As previously mentioned, the bedrock beneath the site was a significant factor in the construction of the Keokuk complex. These three to four foot thick limes one ledges had sufficient thickness and density so that the floors of the locks were left unconcreted (Meigs 1920). Only a few cracks were discovered in the natural floor during the construction process; these were easily filled by grouting, and then tested by air pressure. Thus,

the side walls of the lock were supported in total by the bedrock.

The significance of the Keokuk project lies in the novelty of certain designs, including the circular gates and the pneumatic mode of power. The dam and associated hydro-electric plant were also the largest in the world at the time of original construction. The only problem associated with the plant was cracking in the discharge valves; these were replaced, and no further problems were encountered. In the opinion of Mr. M. Meigs, that:

... all this intricate machinery of novel type should have operated so well is a high tribute to the chief engineer, Mr. H. L. Cooper, and his mechanical assistant, Mr. B. H. Parsons. In six years no boat has been denied passage, though for a month or two it was slow when but one valve was available for unwatering the lock (Meigs 1920:204).

Summary: Contemporary Lock Complexes

The section above reviews significant achievements in lock design during the period from 1900 to 1925. As previously stated, the Panama Canal project was, without doubt, the most significant undertaking of the period; its influence on subsequent lock facilities is obvious. As a result of this discussion, common and novel approaches to lock design in the early years of the twentieth century may be understood. Following description of regional and local lock complexes, the IHNC facility will be described so that any departures from traditional practices may be recognized. Following that discussion, the components of the IHNC lock are compared to those of its predecessors and contemporaries.

Locks in the Region of Southeastern Louisiana

The Plaquemine Lock Complex

The Plaquemine lock is located near the intersection of the Mississippi River and Bayou Plaquemine, twenty-five miles south of Baton Rouge, Louisiana. The lock officially was opened to traffic on July 5, 1906. When completed, it was one of the largest concrete structures of its kind in the world (Swanson 1983). The length of the lock is 260 feet; the width is 55 feet. The lock chamber is filled and drained by means of a gravity feed system similar to that used at the IHNC facility. Although the Plaquemine lock functioned well for 55 years, it eventually became inadequate for modern shipping needs. The Port Allen lock was constructed in 1961 to replace the Plaquemine lock. Since then,

the site of the historic Plaquemine lock has been maintained as a State Commemorative Area.

The necessity for a lock at the head of Bayou Plaquemine had been recognized since the mid-nineteenth century. The Atchafalaya Basin was viewed as a largely underdeveloped transportation route; this route was significantly shorter to the Gulf of Mexico than the full course of the Mississippi River. In 1832, the State of Louisiana hired a civil engineer for the purpose of surveying the state's waterways. The main thrust of this survey was to establish a workable transportation route between the Mississippi River and Bayou Teche to the west. At this time, there were three principal routes:

The first was to the Atchafalaya and then south, to the Teche. The second was to St. Martinville and New Iberia by way of Lake Chetimachas (Grand Lake). The third was to the Atchafalaya, ascending that channel to the Courtableu River, and hence to Opelousas via a number of smaller waterways (Darby 1818:47).

The lock at the head of Bayou Plaquemine was necessary to prevent the flow of water from the river from flooding the lowlands to the south; the canals to the south of the Mississippi were often severly clogged with debris during the months of October and November, when the river was at low stage. This problem was a function of both river stage and of the neglect of smaller channels as a result of the growth of a regional rail system. Because logjams rendered many channels impossible, Bayous Plaquemine and Lafourche emerged as the most reliable routes for shipping. The plan to build a lock at the head of Bayou Plaquemine was delayed by the onset of the Civil War, and by the subsequent collapse of the plantation economy of the region (Swanson 1983).

The clogging of the Plaquemine channel was of great concern to local residents who feared severe flooding from the Mississippi River. Shortly after the Civil War ended, a dike was erected at the head of Bayou Plaquemine near the Mississippi River which greatly eased the concerns of the people. However, by the end of the nineteenth century, lumber and fishing were replacing the older plantation crops and a new, stronger regional economic base was developing. The need for a local navigation channel once again was recognized by local officials.

Many local residents disliked the idea of destroying the dike; Civil War veterans protested the proposal with guns in hand (Swanson 1983). Despite the protests, plans continued to reopen the canal; a lock at the location of the dike would insure flood protection. In addition, the lock would afford river traffic a

shorter route to the Gulf of Mexico by some 150 miles. Thus, the lock would serve two important functions: to control Mississippi River discharge and to reopen Bayou Plaquemine to navigation from the Mississippi River.

The construction of the Plaquemine lock was undertaken by the United States Army Corps of Engineers. The history of the construction project was plagued by both mishaps and poor design decisions. Appropriation of the necessary funds for the project resulted from River and Harbor Acts of the United States Congress in 1882, 1888, 1889, 1894, and 1896 (Swanson 1983). The span of the construction project was fourteen years long, between 1895 and 1909. Excavation at the site began on September 2, 1895. The first contract for excavation was given to Mr. E.A. Burris of New Orleans. Mr. Burris was responsible for the erection of cofferdams, excavation of the lock chamber, and the erection of retaining walls.

The floor of the lock chamber required the driving of nearly 9000 pilings into the clay stratum present below the site. Unfortunately, this clay proved to be inadequate to support the weight of the lock, resulting in structural failures that greatly delayed the project. In addition, the Mississippi River was setting new records of low and high stages during the end of the nineteenth century. As a result, the original design had to be modified significantly to address this issue (Thompson 1897).

Historians have speculated on the exact contribution of Major General George W. Goethals in the design of the lock. There is little doubt as to the expertise which Mr. Goethals possessed in the area of lock design and construction. Although no evidence exists to verify Goethals' direct involvement in the Plaquemine lock, the design of the Plaquemine lock is very similar to an earlier lock constructed by Goethals for the Corp of Engineers at Riverton.

As stated above, a series of mishaps and poor design decisions delayed the completion of the lock for several years. A cave-in, caused by dynamiting to clear the chamber of cypress stumps, necessitated the design and construction of better system of bracing for the side walls. And, the clay stratum beneath the chamber was insufficient to support the weight of the concrete structure. As a result, differential settling occurred and a longitudinal crack developed in the floor of the lock chamber. To prevent the walls from moving too far out of square, the contractor spanned the chamber with 70 two-inch steel bars. Despite this, the chamber actually did widen slightly. As a result, all original designs for the gates had to be revised to fit the "new" dimensions of the lock chamber. These events kept the project shut down for a period of nearly four years (Swanson 1983).

Many other minor repairs were required because of the years of neglect while the project was shut down. The chamber developed several smaller cracks which had to be scraped and patched. In addition, cement wedges were placed in the lock walls to make the gates plumb (Obier n.d.:41). The 70 steel rods finally were removed in September, 1908, and the lock officially was opened to traffic on July 1, 1909 (Swanson 1983).

The gates at the Plaquemine lock are similar in design to those previously described at the Keokuk lock; they form a half-circle when closed. The gravity feed system operates in the same fashion and with similar mechanisms as that at the IHNC lock complex. The Plaquemine lock functioned until the second World War, when traffic associated with National Defense put unrealistic constraints on its capacity. There was immediate concern for the construction of a new, larger lock facility. A new facility eventually was designed and completed at Port Allen; that lock opened to water traffic on July 14, 1961. Shortly thereafter, the Plaquemine lock was closed to Mississippi River traffic. The Plaquemine Lock State Commemorative Area was established in 1977.

The Harvey Lock

The Harvey lock is located on the west bank (right descending) of the Mississippi River, approximately four and one-half miles upriver of the Vieux Carre'. The present lock was constructed by the Army Corps of Engineers in 1933 to replace the historic lock opened in 1909. The length of the 1933 lock is 425 feet; its width is 75 feet. The gates are arranged so that they can withstand a reverse head (on rare occasions the water in the Harvey Canal is higher than the Mississippi River). This lock was designed to accommodate larger vessels associated with the petrochemical industry; it served as a catalyst for commercial development along the Harvey Canal.

The land on which the present canal and lock are located originally was owned and farmed by Jean Baptiste d'Estrehan de Tours in the early eighteenth century; d'Estrehan later was anglicized to Destrehan (Waldemar S. Nelson & Co., Inc. 1985). To improve drainage and move harvested crops, Destrehan had a ditch dug from a point near the Mississippi River southeast to Bayou Barataria. This ditch was widened to accommodate increasing lumber traffic. A town eventually was founded along the banks of this fledgling canal by Destrehan; it was named "Cosmopolite City."

The property was passed down by inheritance through the eighteenth and nineteenth centuries, and it was in the possession of Louise Destrehan (Jean Baptiste's great-granddaughter) who

married a Virginian, John Joseph Harvey, in 1845 (Waldemar S. Nelson & Co., Inc. 1985). The settlement of Cosmopolite was renamed "Harvey," and commercial development replaced residential development. Both Mr. and Mrs. Harvey dreamed of connecting the canal with the Mississippi River to bring steamboat traffic to the villages of Houma and Grand Isle to the south. A lock was designed and constructed between 1880 and 1881; structural problems kept the lock from enduring more than a ceremonial opening.

John Joseph Harvey died in 1882, leaving Louise with a burden of debts; she could not afford to pay for the repair of the locks. The locks subsequently were sold to the Harvey Canal Land and Improvement Co. (the Harvey family corporation) for \$40,000.00. The Improvement Company took over the responsibility of repairing the locks. The official opening of the Harvey locks was March 30, 1907, four years after the death of Louise Destrehan Harvey.

The canal was in continuous operation for 17 years under the jurisdiction of the Harvey Canal Land and Improvement Co. Commercial development along the Harvey Canal flourished during this period. In 1924, the United States Government purchased the canal and locks as an addition to the burgeoning system of inland waterways. The original locks were replaced by a modern facility in 1934; sections of the original complex still are visible today.

As previously mentioned, the dimensions of the present lock are 425 feet by 75 feet; the mean water level is twelve feet over the sill. The gates which face the Mississippi River are single sheathed (on the river side), and they are of the mitering type. No wood is used at the miter joint; the seal is metal to metal, and it is held tight by the difference in water level on either side of the gates. In addition to these primary gates, a set of reverse head gates are located at each end of the lock. These are lower than the principal gates, and they are used when the Harvey Canal is higher than the Mississippi River. It should be noted that these gates have proven to be inadequate since they are too low to hold back water from the canal.

The lock chamber was based on the design of the IHNC project; the two cross-sections are nearly identical. In fact, most of the machinery used to operate the gates and sluices at Harvey have a striking resemblance to the machinery at the IHNC. The difference at Harvey is the size of the machinery and an increased attention to built-in safety mechanisms. There are three separate limit mechanisms associated with the machinery which moves each gate; this greatly reduces the number and significance of damages. All mechanical principles in the operation of both the gate arm and the sluice valves are identical to those at the lock at the IHNC.

The same gravity feed system that was employed at the IHNC

lock is used at Harvey; water travels through two culverts in the lock walls, and enters the chambers through a series of ports at the bottom. The position of the sluice valves or gates are represented by dials on the lock walls. The lock operators must be keenly aware of the location of these gates:

This is a small shallow lock and water comes in here under extreme pressure. Depending upon the size of craft in the chamber, one or both sides (culverts) of the chamber are opened. The water entering from one side rolls when it hits the other wall and forces the larger vessel to one side of the chamber. The culverts and ports on the same side as the larger vessel are always opened when there is a smaller vessel in the lock. (Keith Alexander, Lockmaster, Harvey Lock, personal communication 1986).

The emergency dam system at the Harvey lock also draws influence from the system first used at IHNC. A derrick is located at the Mississippi River end of the lock which lifts stop logs (girders) and places them in recesses in the lock chamber. The stop logs are picked up by a hydraulic ram mechanism which releases the chain and log when it is in place; all five logs rest in a storage yard with chains attached. This system represents an improvement over the IHNC prototype for the following reasons: the stop logs are larger and lighter, so fewer are needed to make a seal; the release mechanism has been greatly simplified; and, the stop logs are fitted with rollers which afford easy passage down the recesses in the chamber. As a result, the logs do not get out of line when they are lowered, and the resulting seal is relatively tight.

One of the greatest difficulties in the operation of the Harvey lock occurs when a large ship, traveling up or down river, motors across the mouth of the Harvey Canal. The wake of these ships lap against the miter gates at the river end of the lock. As previously described, these gates are held tight by a differential in water level. The action of the waves occasionally can pull the gates apart and violently slam them back together. If this occurs, damage is likely to the gate arm, the universal joint, or the bull gear; "something is going to give" (Keith Alexander, personal communication 1986).

The Harvey lock clearly draws its design influence from mechanisms present at the IHNC lock and at the Panama Canal. The machinery at Harvey is somewhat smaller and more efficient; it requires less operational space than at IHNC. Clearly, the precedent set by the construction of the Industrial Canal lock chamber was adopted by engineers even fifteen years later (a

relatively long period of time in the engineering sciences). Therefore, the Harvey lock represents a continuing tradition of the use of precedents set by the engineers of the Panama Canal.

The Algiers Lock

The Algiers canal was dug to handle increased navigation traffic resulting from the connection of the Harvey Canal to the national inland waterway system; the lock was completed in 1953, and it was opened to water traffic in 1956; the lock and canal are located approximately six miles downriver of the Vieux Carre'. The Algiers lock was built much later than the lock in the Industrial Canal; therefore, there are radical design differences between the two facilities. The Algiers locks are in operation 24 hours a day. During one day, an average of 35 lockages occur. The Algiers lock is 760 ft long and 75 ft wide.

The gates at Algiers are of the sector type; they resemble the early quadrant gates described in Chapter VI of this report (Figure 23). It is interesting to note that the gates at the Algiers lock are designed to seal, fill, and empty the chamber. As a result, there are no culverts, ports, or sluices necessary to control the water level in the lock. All the mechanical equipment at the Algiers lock is above the ground. The sector gates are semicircular in shape, and rotate on a pinion located at the floor of the lock. When the gates are opened, they move into recesses in the side of the lock chamber; each gate weighs 110 tons (John Whalen, Head Mechanic, Algiers lock, personal communication 1986).

The emergency dam system used at the Algiers lock is exactly the same as that used at the Harvey lock; in the twenty years between the construction of the two complexes, few changes in the theoretical approach to this system seem to have occurred. The emergency dam derrick and girder storage yard is located at the Mississippi River end of the lock.

The most impressive component of the Algiers lock is the machinery that moves the gates. One hydraulic mechanism is located above ground in a control house; each machine controls a single gate-leaf. The entire space required for the machine is no larger than a refrigerator. The Algiers lock is significantly simpler than either the Harvey or IHNC lock, and it requires less maintenance to operate (John Whalen, personal communication 1986). It is interesting to note the level of mechanical atavism present here; the first leaf gate types discussed in Cripter VI of this report also were bi-functional (Figure 22), i.e., they provided a seal for the lock chamber as well as mechanisms which allowed water to flow through the gates. Theoretically, there are obvious similarities between the gates at Algiers and this early

nineteenth century approach to gate design. The Algiers lock represents a reductionist approach that has done away with many complex features such as sluices and their associated machinery. The cross-section of the chamber does draw definite influence from the IHNC design; this will be described in detail in the following chapter.

CHAPTER VIII

THE INNER HARBOR NAVIGATION CANAL LOCK COMPLEX

Introduction

The purpose of this chapter is to describe the features of the IHNC lock complex, and to assess their significance within the context of early twentieth century structural, hydraulic, and mechanical engineering. The historical context in Chapter VII provides a basis for comparison. Components of the IHNC lock complex that receive detailed treatment in this chapter are the lock chamber, the miter gates, the gate operating machinery, the sluices, and the emergency dam. Each of these features is described below, and the importance, or significance of each feature also is addressed. The construction of the lock complex at the Inner Harbor Navigation Canal enabled completion of the connection between Lake Pontchartrain and the Mississippi River; the lock is located roughly 2,000 feet north of the river. Although navigation is the lock's primary function, the lock complex serves as an important regional flood control device. Normally, the level of the Mississippi River is higher than Lake Pontchartrain (as much as 19 feet); the IHNC lock facility functions to keep the river waters from rushing north into the lake. Occasionally, when the river is at an extremely low stage, the level of Lake Pontchartrain exceeds that of the Mississippi River resulting in what is referred to as a reverse head. lock complex was the first lock designed to handle reverse head conditions; this design incorporated several interesting features that are discussed in detail below.

The important regional issue of hurricane protection also was addressed by the IHNC lock facility. The lock complex was designed to act as a flood prevention device by resisting storm surges associated with hurricanes moving northward from the Gulf of Mexico. An emergency dam mechanism (Figure 35), located at the river end of the lock, can be used to seal off the lock chamber during such conditions; a storm surge is more likely to come from the direction of the lake rather than the river. In fact, any connection between the river and the lake was impossible without the inclusion of an effective means of flood control:

The Mississippi River has a water elevation varying from approximately 1 ft mean sea level to an elevation of +22 ft during project flood stage and Lake Pontchartrain has a low tide of approximately 0 mean sea level to approximately 13 feet during severe storms. Because there is usually a stage difference between these bodies,

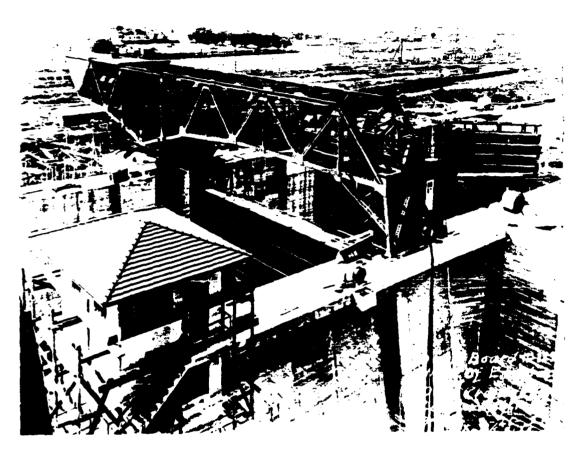


Figure 35. Emergency dam crane at the southern end of the IHNC lock (Courtesy Board of Commissioners of the Port of New Orleans).

there had to be a lock placed between the canal and the river. At the time of the construction there were no significant levees along the canal so any failure of the gates which would allow river water to flow into the canal would flood the lower part of the city so it was necessary to include an emergency dam to close the canal in such a happening (Peyronnin and Hinrichs 1984:2).

The IHNC lock complex was begun in 1918 and completed in 1921; the canal was opened to water traffic in 1923 when the 2000 foot section south of the locks was dredged to the Mississippi River. The project was undertaken by the Board of Commissioners of the Port of New Orleans, and it was funded through local bond issues. The consulting engineering firm hired for both the excavation and construction of the lock was the George W. Goethals Co. Inc., of New York. Major General Goethals and his assistants at the Panama Canal were responsible for some of the most innovative designs of the age in structural, hydraulic, and mechanical engineering. Although Major General Goethals was not directly involved in the IHNC project, many of the components at the IHNC facility are of the same type used at the Panama Canal. Beyond the obvious similarities to the Panama project, local soil and climatic conditions resulted in innovations specific to IHNC; the significance of these features are discussed below.

Lock Chamber

As previously stated, the usable length of the IHNC lock chamber is 600 feet, and the width is 75 feet; the minimum depth on the gate sill is 30 feet. The unstable substrata (see Chapters II and V) meant that the structural design had to be specific to local conditions. The representative of the Goethals Company in New Orleans was George R. Goethals, the Major General's son. In a paper read before the the Louisiana Engineering Society on May 12, 1920, Mr. Goethals stated:

... the design of the lock as a whole differs materially from any heretofore constructed, both walls and floor having been designed on the principle of an integral unit somewhat analogous to the hull of a ship, thus producing a practically uniform loading of the piles, rendering local settlement practically impossible (Goethals 1920:129).

Figure 36 illustrates a typical cross-section of the lock chamber; the right hand side of the figure shows the placement of the steel

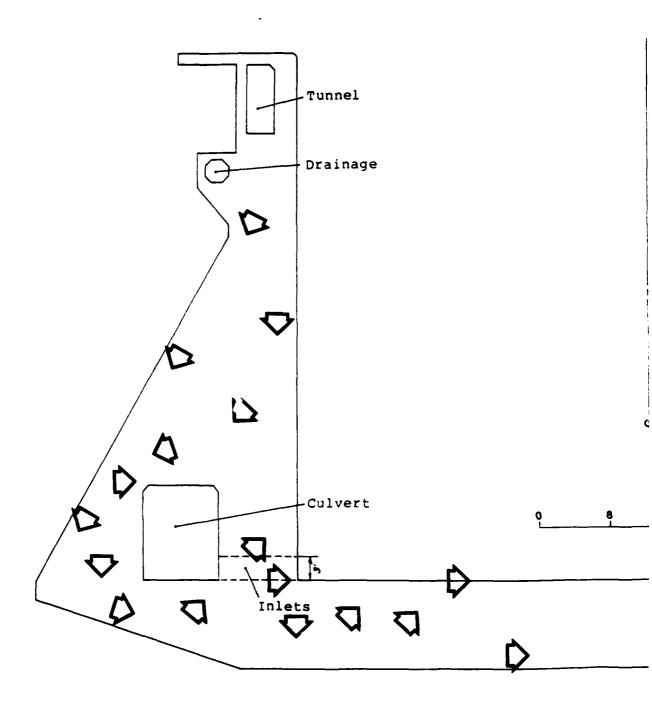
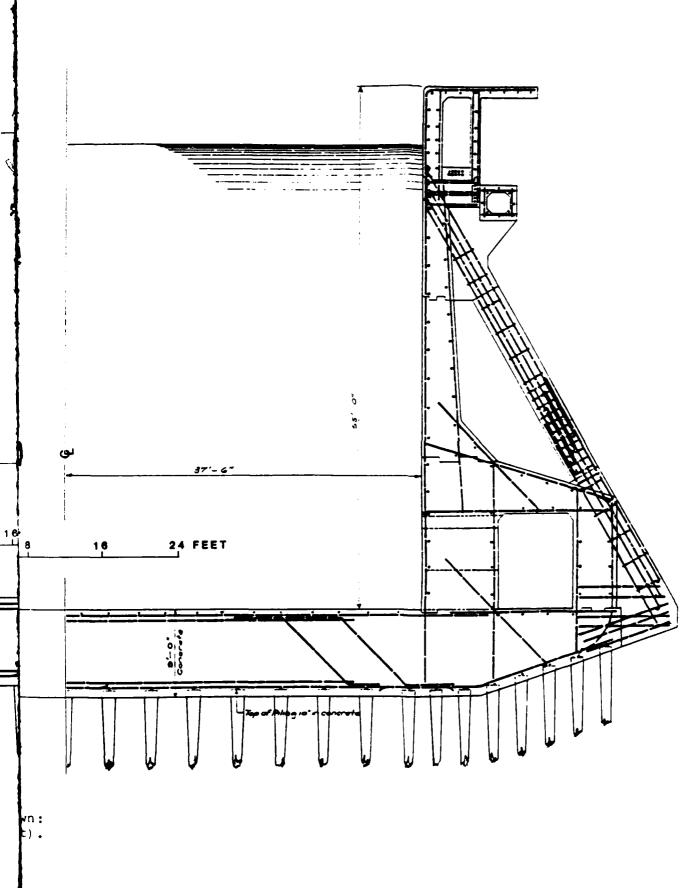


Figure 36. Typical cross-section of IHNC lock chamber (redrawn: Courtesy Corps of Engineers, New Orleans District).



reinforcement, while the left side schematically illustrates the transfer of loads. In order to produce the uniform pile loading described above, the steel was arranged so that vertical loads were transferred horizontally. The side walls of the lock chamber were chamfered (angled out) to provide the necessary width in section to accommodated the steel. This technique apparently had never been attempted before; reinforced concrete was still a relatively new construction medium in 1918.

Within this concrete section (the lock chamber), various functions had to be accommodated, thereby precluding a solid cross-section. As Figure 36 shows, the tunnel continues along the entire length of the chamber between the sets of gate machinery. Too, all seepage and condensation is moved to pump wells by means of a drainage culvert; the water then is discharged from the wells by electrically operated sump pumps. The lock is filled and emptied by means of two culverts on either side of the chamber. Sluice gates control the flow of water through the eight-foot culverts. The water enters the lock chamber through ports at the base; these are three feet square, and, there are fifteen ports on either side of the chamber. Water is moved through the culverts by gravity.

The settlement of the lock chamber has been relatively even; elevations surveyed within the last few years show the complex to be rebounding (rising) only very slightly. The initial settling was anticipated by the Goethals Company. When the concrete was poured, the sides of the lock chamber were scored in a block pattern. The function of this scoring was to control cracks which would develop in the wall. Theoretically, if weak points are designed into the wall, cracks will occur at those locations and thus be limited to easily manageable horizontal and vertical fissures.

The significance of this particular approach to structural design lies in the fact that this was the first application of previously theoretical techniques of reinforced concrete construction. Because the conditions at the site required a solution to lock chamber design not previously attempted, the true limits of the interaction of steel and concrete were tested at the IHNC complex. The resultant construction has proven to be an excellent solution to the problem: in sixty plus years of continuous operation, no significant structural modifications have been necessary. The IHNC lock chamber employed a number of original design features that made a significant advance in structural engineering.

Miter Gates

The miter gates at the IHNC lock complex are nearly identical

to those used at the Panama Canal. Because of the possibility of the water level in the lake exceeding the height of that in the river, two sets of reverse head gates were installed at the IHNC. Figure 37 shows the location of the gates at the complex; Gates 1, 2, 5, 6, 7, and 8 face the river, while gates 3, 4, 9, and 10 are the reverse head gates and face the lake to the north. If a serious storm were to threaten the city, both the river and the lake (reverse head) gates could be closed to seal both the lock chamber and the Industrial Canal.

The gates are exemplars of the double sheathed type used at the Panama Canal (Figure 38). They are curved slightly at the miter and quoin (hinge) end to reduce static pressure while opening and closing. The gates were designed so that they are interchangeable if one gate is damaged. The operation to move the gate is fairly straightforward; it is facilitated by the air chambers in the gate:

Roughly, the gates weigh about 88 tons (buoyancy weight). Dead weight is about 200 tons. So, if you just pick it up off of the spindle (on the bottom)... it floats by itself, so to speak. It is a lot easier to move it in the water. The gates have air chambers on the bottom; five air chambers on the bottom and four water chambers on the top. So you have water on the top of your air chambers, they keep it down; keep it from floating.... I have seen them moved; they moved five and six to repair them.... They have a crane that picks them up and moves them back. They're interchangeable (Captain David Cobb, IHNC Lockmaster, personal communication 1986).

The gates are kept square with the lock wall by a set of turnbuckles located at the top quoin end of each leaf; the turnbuckles are accessed through steel grates placed in the slab above. Figure 39 shows the location of the turnbuckles at the left hand side of the gate leaf. An elevated walkway is located on top of each gate leaf; when the gates are closed, these allow access to the other side of the lock. On the lock floor are the gate pits; these are recesses designed to allow sediment and debris to settle below the gates. They do not interfere with the operation. All watertight seals associated with the gates use greenheart timber (Nectandra radioei). This wood is native to Guyana, and it is especially hard and water resistant. Greenheart is used at the miter edges of the gate, at the quoin end, and at the clapping sill (Figure 40). The clapping sill is located at the edge of the gate pit where it serves to limit the motion of the gate; it provides a relatively watertight seal at the bottom.

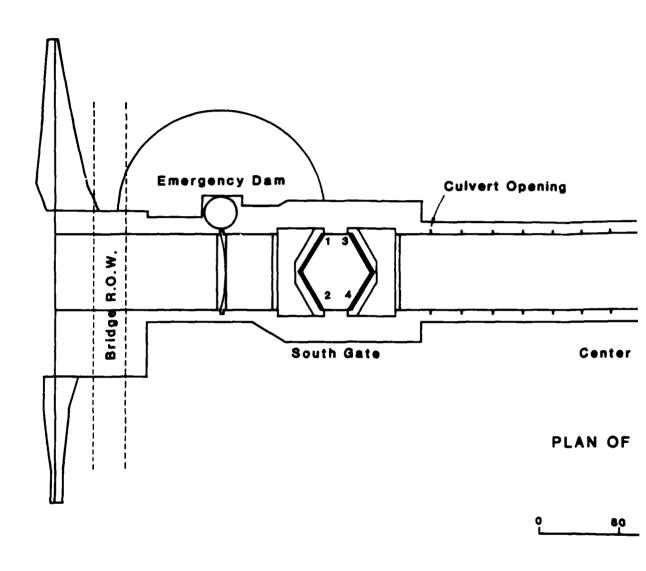
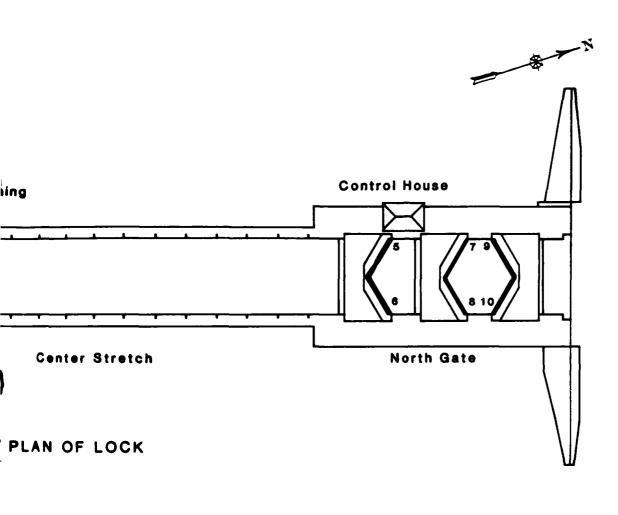


Figure 37. Schematic plan of IHNC lock (redrawn; Courtesy Corps of Engineers, New Orleans District).

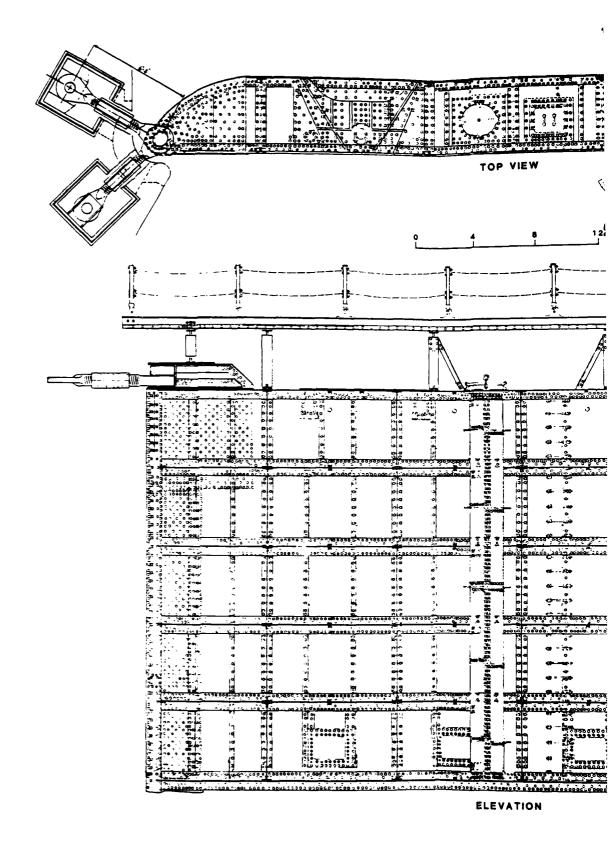


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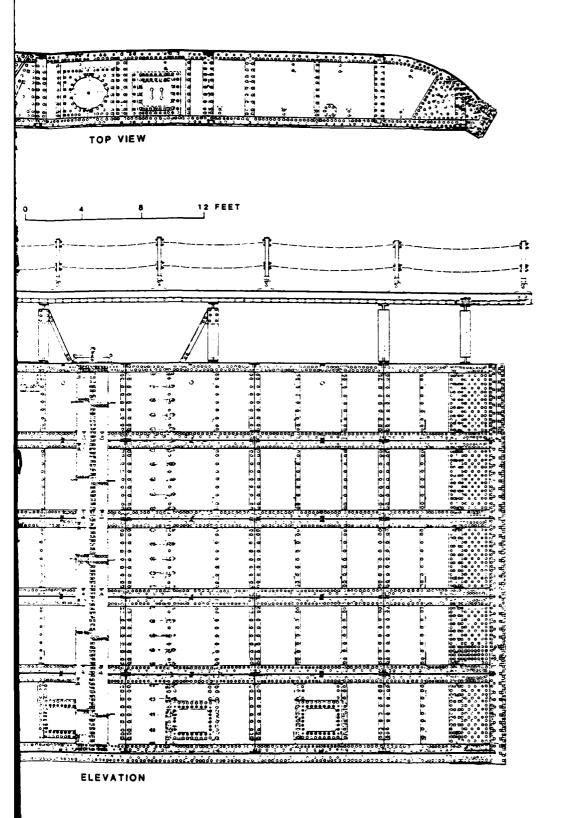


Figure 38. Gate at IHNC during construction (Courtesy Board of Commissioners of the Port of New Orleans).



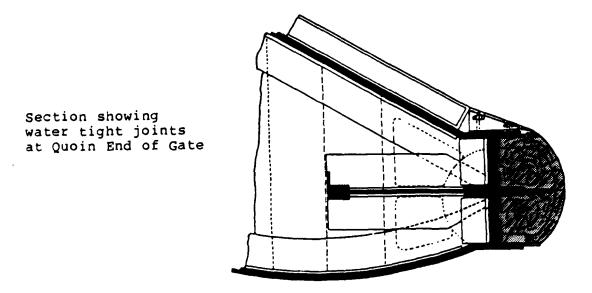
MITERING LOCK GATE - UPSTREAM SIDE

Figure 39. Plan and elevation of gates at the IHNC lock (Courtes: Corps of Engineers, New Orleans District).



K GATE - UPSTREAM SIDE WATER CHAMBER

the IHNC lock (Courtesy District).



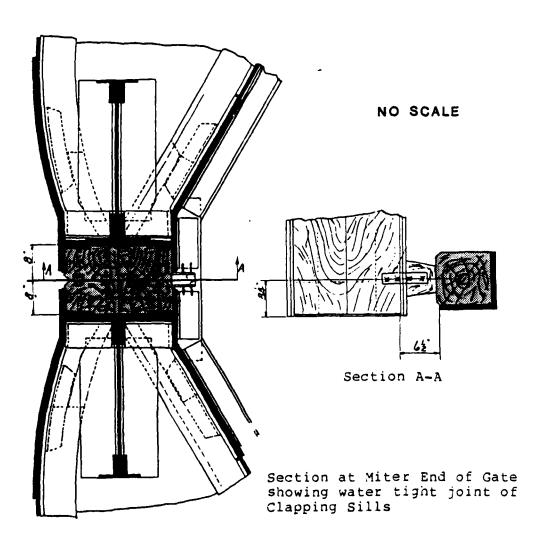


Figure 40. Location of Greenheart Timber for watertight seals at the IHNC lock (Courtesy Corps of Engineers, New Orleans District).

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Although the use of miter gates at the IHNC lock may have been dictated by governmental policy, it appears to represent the first use of Panama-type gates in the United States. These gates require only occasional maintenance, which will be described subsequently; over the years, they have performed their function well.

Gate Operating Machinery

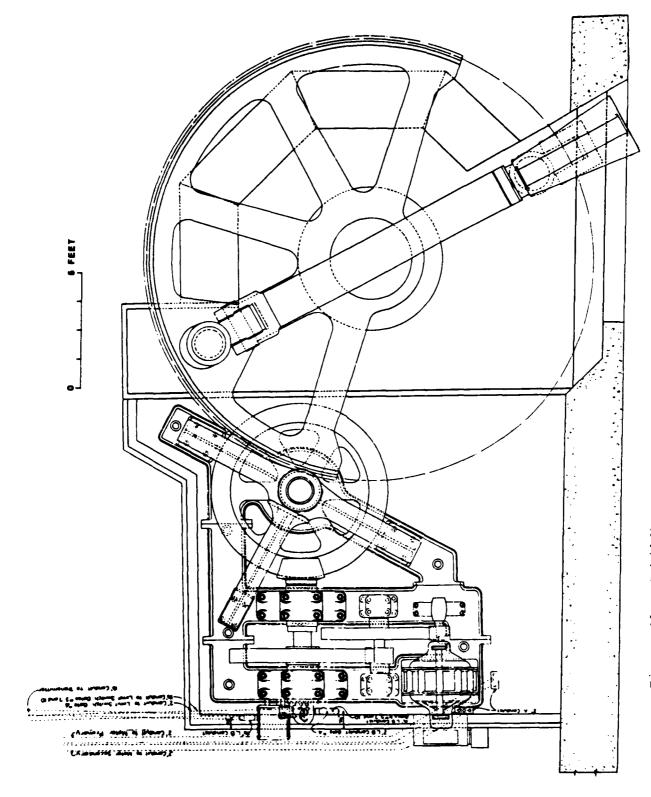
The gate leaves at the IHNC are opened and closed by use of the Schildhauer electric gate machines first used at the Panama Canal. The miter gate operating machinery is actuated by a 52 horsepower electric motor which operates at 570 r.p.m. The electric motor then drives a gear train consisting of spur and bevel reduction gearing. The gate is attached to the spur wheel by a strut arm; three buffer springs in place at the gate end of the strut arm function as shock absorbers in the event the gate is struck by or opened against a reverse head. The gate's movement is controlled by a limit switch atop the miter gates. When the seal is complete, the limit switch is tripped and the motor is turned off.

The only difference between the Schildhauer machines at the IHNC and those used in Panama is the shape of the spur wheel. Figure 41 is a drawing from the original set of plans of the IHNC lock; it shows the half circle shape of the spur wheel. By comparing this drawing to Figure 28, the machines at the Panama Canal, the difference between the two are clear. The spur wheel at the Panama Canal is a full circle geared on only half of its circumference. The spur wheel at IHNC is only a half circle and thus requires less space.

The Schildhauer machines at the IHNC lock complex represent the first use of this mechanism in the United States. The significance of the development of this mechanism was discussed previously. The machines at the IHNC, therefore, represent a modification of the original Panama Canal design. As noted above, one of the most important factors associated with the Schildhauer mechanism was economy of space. The use of a half circle spur wheel at the IHNC represents an important modification to a significant piece of machinery; even less space was required for the machines at IHNC. The Schildhauer gate machines at the IHNC lock complex represent a significant advance in the mechanical engineering of the period.

Sluices: The Movement of Water

The level of water in the lock chamber is controlled by the opening and closing of the sluice valves. There are two sets of



Schildhauer Gate Machine, IHNC lock (Courtesy Army Corps of Engineers, New Orleans District). Figure 41.

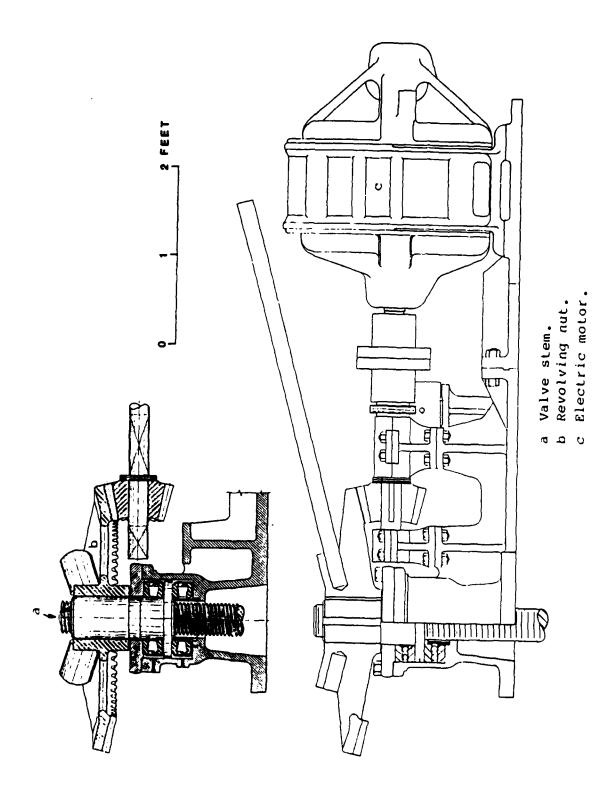
sluice valves on each side of the lock chamber at both the river and lake end of the complex. The second sluice valve is used in case of breakdown, as well as during maintenance of the primary valve. The sluice gates are located within the culvert; they operate much like large steel garage doors. At the top center of each gate, a threaded rod or valve stem is attached. Figure 42 illustrates the machinery which operates the sluice valves or gates: The valve stem (a) is threaded through the revolving nut (b). When the reversible electric motor (c) is actuated, the revolving nut spins, raising or lowering the valve stem and thus the gate in the culvert. The vertical movement of the valve stem is kept in check by a limit switch which turns off the motor when the gate is fully raised.

The sluice gates slide up and down along steel rails bolted to the walls of the culvert (Figure 43). The water enters the culverts at two locations on each side of the lock chamber. One opening is located at the river end of the lock between the emergency dam and gates 1 and 2; the other opening is at the lake end, just north of gates 9 and 10. A lockage occurs in the following fashion:

If we are locking from the canal, that is, the ship is entering the lock from the canal side, the miter gates at the canal end are opened and the ship comes in and ties up. Then we close valve (sluice) on the canal end, and open the valve on the river end. The water from the high side of the chamber (river in this case) will come into the culvert, and go into the lock chamber itself through the ports at the bottom. It is a smooth up and down motion; there is no turbulence in the lock chamber (Captain David Cobb, personal communication 1986).

The methods and machinery described above seem to have been quite common during the early twentieth century. Similar sluice valves were employed in the side walls at Panama; mechanisms of this type were used before the Panama project. Although these systems at IHNC are excellent and have proven their worth through continuous operation, they are not particularly significant because they represent a common, rather than a prototypical design.

All gate and sluice machines at the IHNC originally were designed to be operated from a single point; this was in response to the precedent set at the Panama Canal several years earlier. The lockmaster's house was equipped with a control panel (Figure 44) which allowed the operator to gauge both the level of water in the lock and the position of the gates. Unfortunately, the placement of the control house at the extreme North end of the lock made it



Sections of sluice valve machinery at IHNC lock (redrawn: Courtesy Corps of Engineers, New Orleans District). Figure 42.

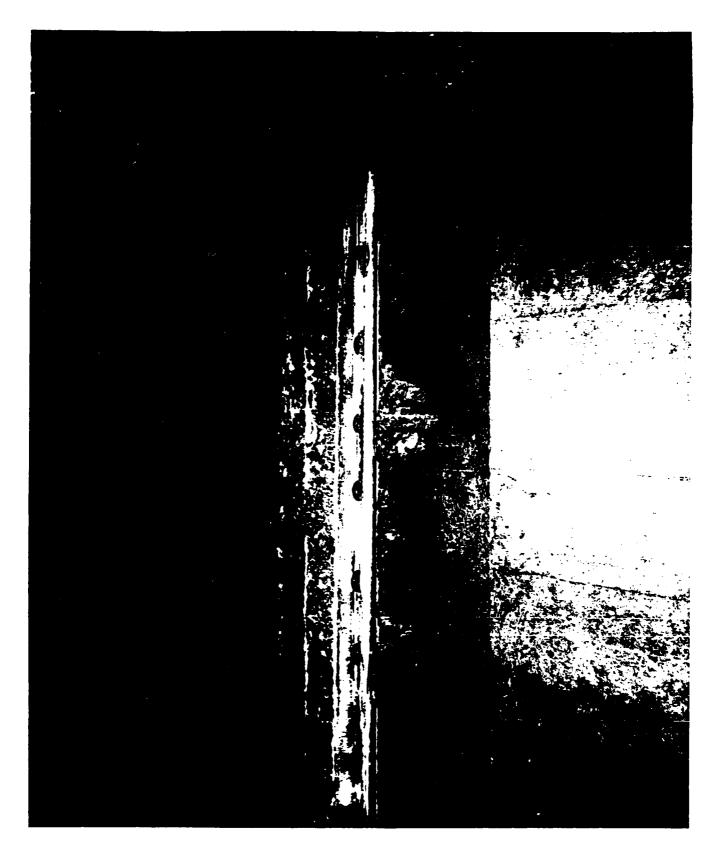


Figure 43. Guide rail and sluice gate at IHNC (Courtesy Corps of Engineers, New Orleans District).

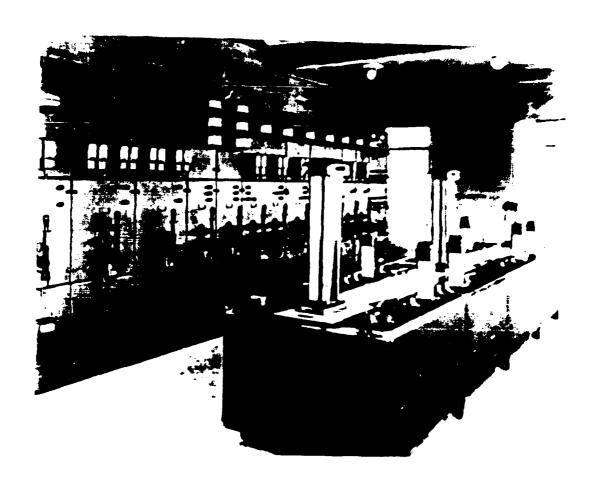


Figure 44. Original arrangement of control panel for operation of gates and sluice machinery (Courtesy Board of Commissioners of the Port of New Orleans).

very difficult for the operator to maintain visual contact with activities at the South end; this was seen as a potentially hazardous situation. As a result, the control panel shown in Figure 44 eventually was abandoned, and a series of small control booths were erected along the lock wall so that operators could observe as well as operate.

The Lockmaster's house itself remains an integral part of the lock complex. While it does not retain its original function, as the operations center of the lock, it serves as the office complex for the lock and its personnel. In addition, the original control devices, including the model of the lock, remain in the Lockmaster's house. This building is considered to represent a component of the lock essential to the proper understanding of the operation of the lock.

The Emergency Dam

The emergency dam at the IHNC lock facility is regarded as one of the most unique and controversial structures of its type (Peyronnin and Hinrichs 1984). The dam (Figure 45) provides a seal in the case of a damaged gate; the dam also is used during periodic maintenance dewaterings. The location of the dam and girder storage yard can be seen in Figure 37. Prior to the construction of the emergency dam at IHNC, the most commonly used emergency dam mechanism was the wicket type used at the Seattle Ship Canal (see above). The wicket system had marked difficulties in maintaining water-tightness. The girder and crane mechanism designed at the IHNC is faster to place and it provides a better seal than the wicket system:

Henry Goldmark, in a paper delivered to the American Society of Civil Engineers in December 1927 described the new concept of the dam for the New Orleans Lock. It is of the stop-log type in which heavy "logs" made of steel were to be placed across the lock into recesses by a crane built into the lock. He credits the idea to a suggestion by R.O. Camer, Design Engineer for the New Orleans Port Commission, although the idea had been used in a simplified version on many power plants to de-water the turbines and in drainage installations to de-water the pumps. Basically, the dam consists of three major parts, the logs, the c-ane, and the hoisting mechanism (Peyronnin and Hinrichs 1984:2).

Figure 46 shows the various components of the emergency dam system. Eight girders are needed to form the complete dam from the lock

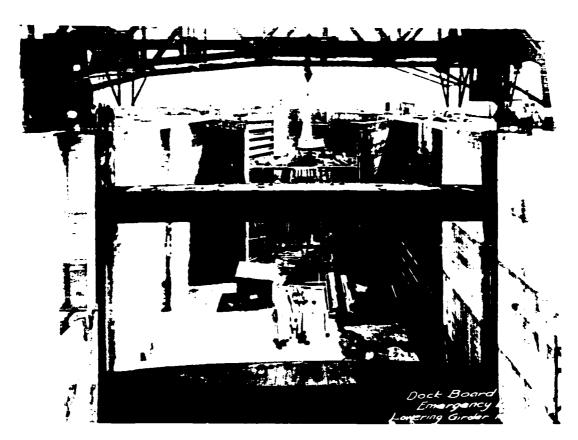
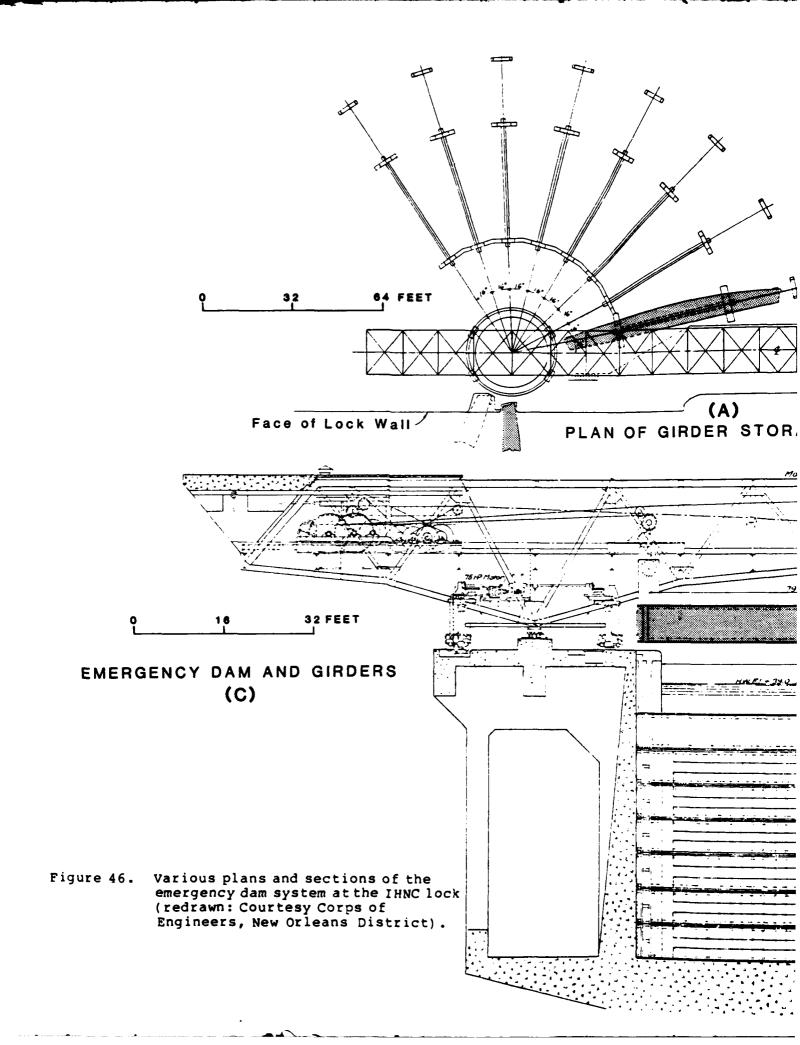
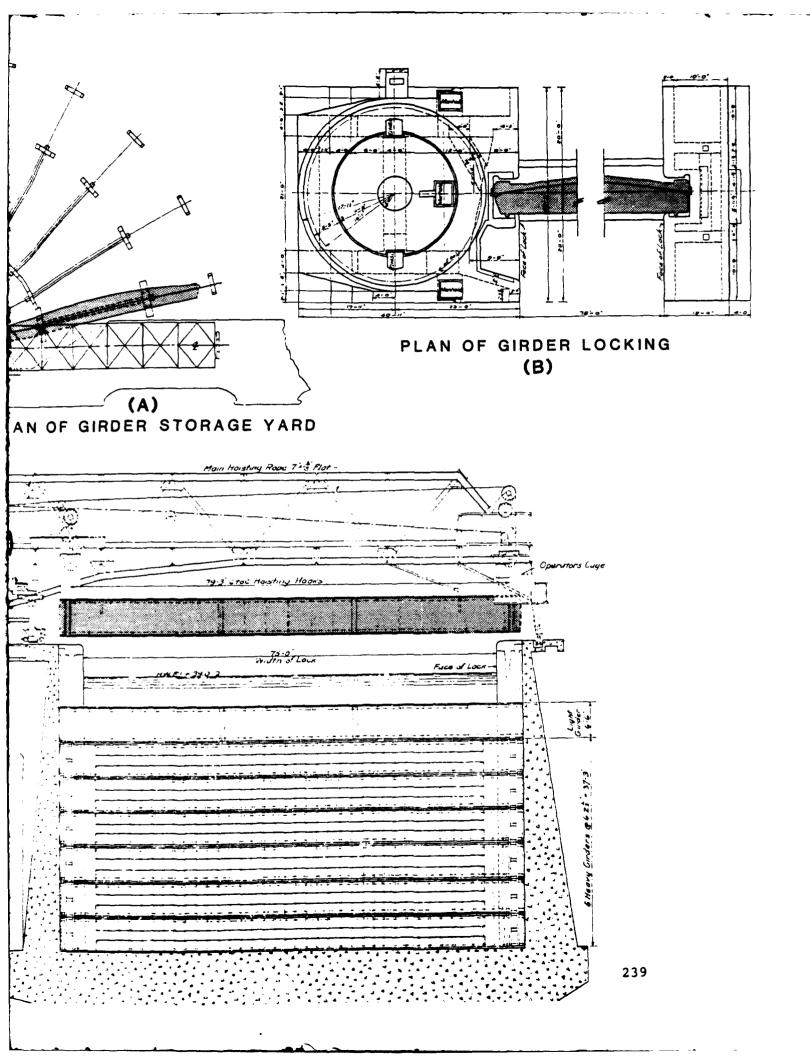




Figure 45. Girders being loaded into chamber to form emergency dam and completed structure (Courtesy Board of Commissioners of the Port of New Orleans).





floor to the top; these girders are stored on concrete platforms in the storage yard (a). The crane (much like a railroad bridge) and hoisting mechanism lift the girders one at a time, pivoting them on a central hub until they are in position perpendicular to the lock chamber (b). The hoisting mechanism is operated by a 300 horsepower electric motor. The pulley system which lifts the girders is moved by a 3/8 inch x 7 inch steel belt (Figure 47). The girders (84 feet long) are slightly longer than the chamber is wide; recesses are provided in the walls of the chamber to accept the girders (c). The first six girders each weigh 88 tons, while the last two weigh 39.5 tons each; the lighter ones are designed for a lesser hydraulic load (Peyronnin 1984). All of the girders or stop logs are designed so that they can be placed in the water and floated to the other end of the lock chamber where there is an identical recess. At the lake end of the lock, the girders are raised and lowered by means of an auxiliary pulley operated by a capstan (normally used to move ships into the lock).

The mechanism designed to pick up and release the logs is of particular interest. Figure 48 illustrates the operation of this mechanism:

The logs are picked up by hooks in the sinker which has a unique system for release.... The hook can rotate on a shaft in the sinker. Attached to this hook is a fin-like projection pivoted to an arm. Inside each log at each end is a bell crank mechanism to which a spring is attached. This spring is compressed by a plunger which extends below the log.... As the sinker descends, the hook is cammed outward by a shaft in the log to which it will ultimately be It drops below the shaft and is engaged. restored by the weight of the arm. The spring will keep it in contact with the shaft. As the log is set upon another log in the dam, or upon the base if it is the first log, the plunger compresses the spring and causes the bell-crank to become a spring loaded trip lever. As the hook drops slightly this crank will force the hook free of the shaft so that the sinker can be raised... (Peyronnin and Hinrichs 1984:4).

The controversy surrounding the design of the IHNC emergency dam centered around the complexity of the design, and the accepted use of the wicket system. After all, a wicket dam was used at the Panama Canal. The actual cost of a wicket system was somewhat greater than that of the girder system. In general, the emergency dam at the IHNC has been used successfully for dewaterings and emergencies. The Galaxy Faith accident in 1972 proved that the

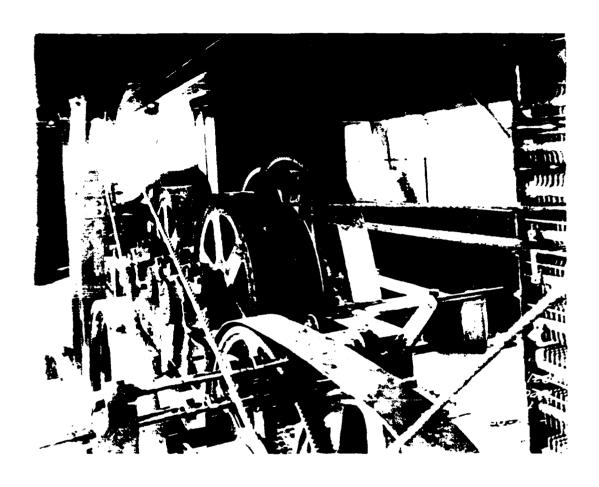


Figure 47. Pulley system which operates the emergency dam mechanism at the IHNC lock (Courtesy Board of Commissioners of the Port of New Orleans).

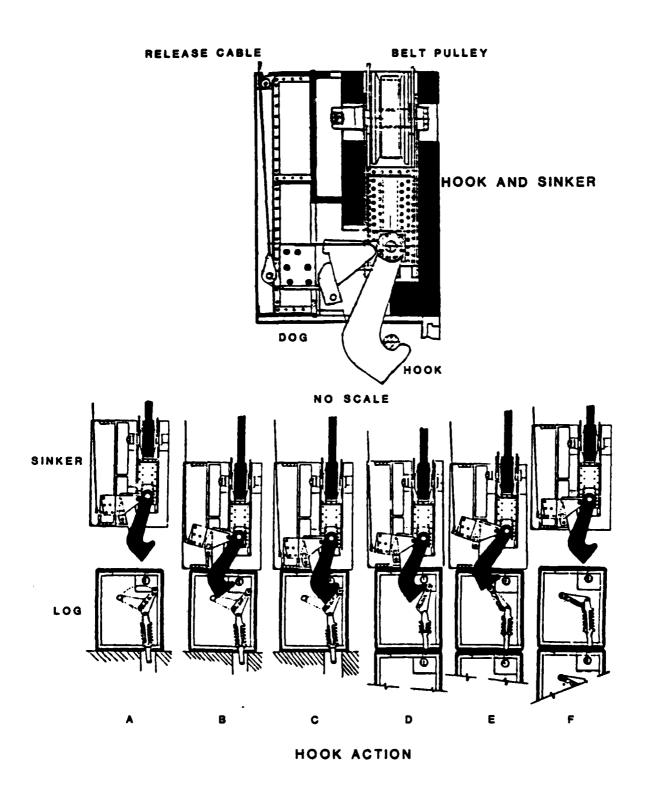


Figure 48. Operation of hooking mechanism designed to lift emergency dam girders at IHNC lock (redrawn from Peyronnin 1984:Figure 6).

fifty year old apparatus was valuable and reliable; the events surrounding this accident will be described in Chapter VIII of this report. The IHNC emergency dam represents a significant mechanical design associated with lock technologies.

Summary

The IHNC lock complex possesses a number of significant components that are exemplars of their type and period. As described above, the design of the lock chamber set a precedent in reinforced concrete construction. The design was necessitated by the adverse soil conditions present between Lake Pontchartrain and the Mississippi River. The massive quantity of concrete used at IHNC could not have been placed successfully without the techniques employed. In addition, the Schildhauer gate machines represent both the first American use of the mechanisms, and an improvement on the original design. The gate machines used at IHNC were designed so that they require less operational space than those at the Panama Canal.

The emergency dam mechanism was the first of its type ever designed and implemented in a navigation lock. It is interesting that while the Goethals Company was contracted to design the lock, a local engineer working for the Port Commission actually was responsible for the idea. The system has proved to be invaluable, and it still operates despite the fact that it is over sixty years old.

Finally, the essential role which the IHNC lock complex plays in local flood control and hurricane protection also is significant. The lock was the first designed to accommodate a reverse head situation. This is seen in the gates which bevel towards Lake Pontchartrain. As noted above, all miter gates at the IHNC resemble those at the Panama Canal; their use as reverse head controls represents both an engineering precedent and an adaptation to the local setting. These four aspects of the IHNC lock complex are important exemplars of twentieth century mechanical engineering methodologies [36 CFR 60.4 (c)].

CHAPTER IX

THE PORT OF NEW ORLEANS

National and International Prominence

Since the second quarter of the nineteenth century, New Orleans has been a major port in national and world commerce. By 1840, New Orleans was ranked as the fourth largest port in the world in shipping and trade; it was surpassed only by London, Liverpool, and New York (Board of Engineers 1947:187). There are many reasons for the Port's success; chief among these is geography. New Orleans is at the terminus of the vast Mississippi Valley, where water and rail transportation bring products from throughout the midlands for shipment through the Gulf of Mexico to other parts of the country and the world. Furthermore, man-made improvements in navigation increased the port's prominence as a center of commerce. For example, the construction of the Panama Canal had a far-reaching effect on the Port of New Orleans. The Port had an immediate advantage over other major U.S. ports because of its close proximity to the Panama facility (Harvey 1904). As a result of the opening of the Panama Canal, shipping from the Pacific to New Orleans increased greatly.

The Port also benefited from improvements to navigation in the upper reaches of the Mississippi River, and from the construction of navigation channels along the Gulf Coast and elsewhere in southern Louisiana. These include the Gulf Intracoastal Waterway, the Mississippi River-Gulf Outlet, and the Inner Harbor Navigation Canal. By increasing the navigation paths into the Port, these channels boosted shipping traffic.

Partly because of the various improvements in navigation, and due to a favorable geographic position, shipping and trade in New Orleans increased over time, maintaining the position of the Port as one of the top U.S. trading centers. Table 2 shows export and import figures for selected periods of time from 1821 through 1965; these figures are expressed in terms of dollars and tonnage. The general trend of growth in trade is evident; declines historically have been correlated with national or world economic declines, such as the Civil War and the Great Depression.

To maintain its position in shipping and trade, the Board of Commissioners has attempted to evaluate and upgrade the Port facilities. For example, in 1969 a master study was commissioned to identify needed improvements. The study, called "Centerport, U.S.A.," presented a number of ideas for modernizing the Port. Among these were a terminal for handling container cargo, and new terminals for barge carriers (Carlson 1983:2a). Projects

Table 2. Patterns of Foreign Trade in New Orleans, $1821-1965^{\frac{1}{2}}$ (Carlson 1983).

Period (Inclusive)	Average Value Exports/Yr. (millions)	Average Value Imports/Yr. (millions)	Average Tonnage Exports/Yr. (millions)	Average Tonnage Imports/Yr. (millions)
1821-1835	15	7	*	*
1836-1851	35	10	*	*
1852-1860	78	16	*	*
1861-1865	4	3	*	*
1866-1880	85	13	*	*
1881-1890	87	11	*	*
1893-1896	77	17	*	*
1891-1900	97	17	*	*
1901-1910	150	37	*	*
1911-1916	184	81	4	2
1917-1921	443	146	5	4
1922-1930	330	186	5	5
1931-1940	162	100	3	3
1941-1945	304	240	3	3
1946-1956	845	513	6	4
1957-1965	*	*	12	5

 $^{^{1}}$ For the period 1821-1842, fiscal ended September 30; for 1843 and 1956, fiscal years ended June 30. For 1911-1965, tonnage years were calendar years.

^{*}No data available.

currently are underway to implement the needed improvements.

The Inner Harbor Navigational Canal was another project designed to upgrade the Port so that it could continue to compete in national and world trade (Board of Commissioners of the Port of New Orleans 1922a:10). The objective of this construction was to expand commerce. This chapter examines and evaluates the operation and success of the IHNC in promoting commerce.

Operations and Jurisdiction

Since its conception, the ownership and operation of the IHNC lock have been under the jurisdiction of either the Board of Commissioners of the Port of New Orleans or the New Orleans District, U.S. Army Corps of Engineers. The relationship of these agencies to the lock has changed over time. As previously indicated, the Board of Commissioners of the Port of New Orleans (the "Dock Board") was the agency given the authority to construct the Inner Harbor Navigation Canal and Lock complex. This authority was granted through State Act No. 244 of 1914 (Carlson 1983:12). The lock was completed in May, 1921, and it officially was opened for shipping traffic on February 6, 1923. From early 1923 to April 1, 1944, the lock was operated solely by the Dock Board. The facility's operations and maintenance were delegated to the Board's Engineering Department.

The Board's Chief Engineer had ultimate responsibility for overseeing the construction of the lock and its subsequent operation and maintenance (Board of Commissioners, Port of New Orleans 1922b:3). His immediate assistant was the Superintendent of the canal; a lockmaster also was appointed. The lockmaster was responsible for supervising the day-to-day operation of the lock, including the hiring, scheduling, and firing of lock gate operators, the St. Claude Bridge operator, and maintenance personnel. He also was responsible for the handling of emergencies. The original organizational structure also allowed for special pilots to be hired to guide ships through the lock (Board of Commissioners of the Port of New Orleans 1922b:3-4). Such pilots were employed initially, but they soon were discontinued. The Engineering Department was responsible for the maintenance of the lock complex. Maintenance requirements or structural modifications were handled by private construction companies.

On March 17, 1944, the Board of Commissioners of the Port of New Orleans and the United States Government entered into a lease agreement; the lease went into effect in April of that year. Through this lease, the New Orleans District, Corps of Engineers, took over the lock's operation and maintenance. It also took over

the management of the portion of the canal from the river to its junction with the Gulf Intracoastal Waterway. This lease previously had been authorized by the Rivers and Harbors Act of July 23, 1942 (Public Law 675-774 Congress). The Corps paid for all "minor" maintenance, while the Dock Board was responsible for "major" maintenance expenses. The cutoff point between minor and major maintenance was placed at \$500.00. The management structure for the lock also was turned over to the Corps at the commencement of the lease. The position of responsibility went to the District Engineer. The lockmaster, operator, and maintenance positions remained as before. The Corps usually used its own personnel to handle maintenance. Repairs costing more than \$500.00 were billed to the Dock Board, or subtracted from the annual rent payment. The latter procedure was a point of contention for the Dock Board, particularly when the Corps sought remuneration for work that the Board maintained was not its responsibility.

In addition to the main lease agreement, four subsequent supplemental lease agreements were signed on February 8, 1965. The first three supplemental agreements did not change the basic terms of the original lease. The fourth, however, affected the terms of the original lease by changing the annual rent from \$240,000.00 to \$1.2 million. All other terms of the original lease remained the same. The enactment of the last supplemental agreement was necessary because of inflated economic conditions and the associated loss of revenue for the Dock Board. At the same time that the last supplemental agreement was signed, the Corps of Engineers and the Dock Board entered into another agreement of farreaching importance:

In this agreement, the Port of New Orleans is required to furnish all lands, easements, right-of-ways, and dredge spoil disposal areas to the United States of America, at no cost, in return for the construction of a replacement lock, and for the provision and maintenance of highway bridges over the waterway as authorized under the Act of Assurance executed by the Port Commission on April 4, 1957 - following on Act on Congress of the United States approved March 29, 1956 (Public Law No. 445-84th Congress, 2nd session).

This agreement took effect on July 1, 1986. On this date, the Corps of Engine_rs acquired full ownership and control of the lock, as well as the right to design and construct a replacement lock when desired.

Development of the Industrial Canal Zone

Although the Board of Commissioners passed a number of measures to encourage development in the Industrial Canal Zone, industry was slow in coming. A variety of economic and political factors worked to deter this growth. At the beginning of World War II, these forces dissipated, and the canal zone began to develop steadily, eventually achieving the industrial complex that exists today.

As previously noted, the great potential of a navigation canal between Lake Pontchartrain and the Mississippi River had long been recognized. Such a link would not only improve commerce into the Port of New Orleans, but it also would assure better and safer water transportation for military vessels in time of war (H.Doc. 133, 1827:15). The importance of this linkage to shipping was enhanced in the early twentieth century by the increase in ship traffic resulting from the construction of the Panama Canal. Thus, navigation was the primary reason for construction of the Industrial Canal.

However, as plans for the project evolved, the potential of the canal as an industrial center began to be understood (Ford, Bacon, and Davis 1915:17). Promoting the canal's use for industry would be an important step in shifting the Port's role from a transshipment point to a manufacturing center. A.M. Lockett, Vice President of the Dock Board, expressed this sentiment in his evaluation of the Dock Board's function with respect to the soon-to-be completed canal:

Before the conception of the Industrial Canal, the sole function of the Board was to increase the commerce of the Port. When the Legislature empowered and instructed the Board to construct the Industrial Canal, it imposed another duty upon the Board. That duty is to foster the industrial development of New Orleans (Board of Commissioners of the Port of New Orleans 1922a:47)

In mid-1922, about a year prior to the canal's completion, the board began receiving reports and recommendations from the Port's Consulting Engineer, J.F. Coleman, on measures to be taken to promote industrial growth in the canal zone. It was recognized that those suggestions did not guarantee that industry would be attracted. As Coleman noted,:

There is no means whereby it may be definitely demonstrated through any system of logical deduction, just how the business of the canal

will develop; nor may more be done in forcing development than to meet reasonable and practicable demands of possible business, in such manner as to invite, and foster the growth of business thereon (Board of Commissioners of the Port of New Orleans 1922a:21-22).

Three kinds of measures for encouraging industry in the canal zone were defined by Coleman in his letter to the Port Commissioner dated July 7, 1922 (Board of Commissioners of the Port of New Orleans 1922a:20-21). These were: provisions for lateral canals; incidental construction items; and, construction of a deep sea canal. Immediate action could be taken regarding the first two categories. The last was seen as a future inducement to development.

Lateral canals (Figure 49) offered businesses access to the canal off of the busy main channel, enabling easier loading of vessels. Also, in the case of a larger industry surrounding a lateral, the lateral would be a private access channel for the business. From the perspective of the Dock Board, lateral canals were desirable because they greatly increased the total frontage area of the canal, and thus the area that could be leased. This, in turn, increased development potential. In addition, arrangements could be made to extend the laterals beyond the boundaries of the canal zone onto private land, enabling industrial expansion beyond the limits of the Dock Board's property. Through lateral canals, industry could be expanded almost indefinitely.

Under incidental construction items, Coleman included a variety of facilities which the Dock Board could authorize, such as marginal roadways and "quay walls, piers, basins, sheds, and warehouses" within its property (Board of Commissioners of the Port of New Orleans 1922a:21). Prior placement of these necessary facilities would reduce initial capital investment costs for potential businesses, making lease areas along the canal more attractive. Other facilities whose prior placement would be an incentive to businesses included the paving of approach roads, the placement of railroad tracks, sewer and water pipes, gas and power lines, and other similar services.

The deep sea canal would be an inducement to future growth. Like the Industrial Canal, it would provide a deep water channel along which dock facilities could be set up, greatly reducing travel time to the Gulf of Mexico. The connection of this channel with the Industrial Canal would funnel shipping traffic into the latter canal, thus accelerating commerce in this area, and in turn, attracting more industry. It is interesting to note that upon the construction of a deep sea canal, eventual government take-over of

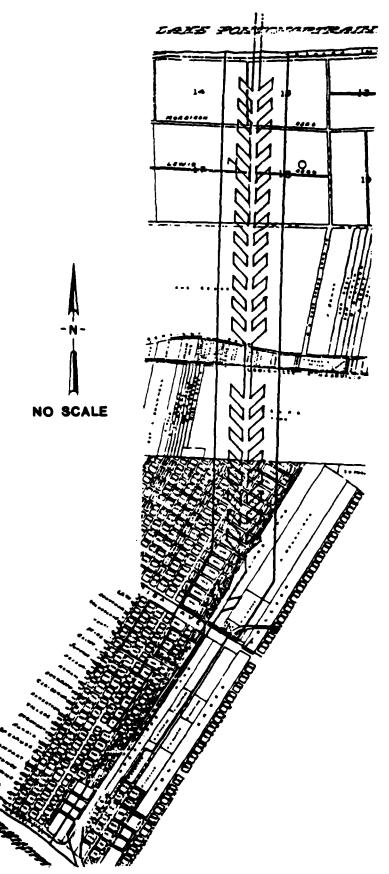


Figure 49. Location of lateral canals along the Industrial Canal (after Stiegman 1971:35).

the Industrial Canal and Lock Complex was predicted. Coleman stated:

When this Deep Sea Canal is constructed, it is to be expected that the Government will take over the operation and maintenance of the Inner Harbor Canal and its Locks, at which time these facilities will doubtless be made free of fees and charges upon the vessels using them (Board of Commissioners of the Port of New Orleans 1922a:41).

The Dock Board accepted Mr. Coleman's recommendations, and it proceeded to pass a number of ordinances governing the construction, leasing, and rent fees of lateral and sublateral canals, bridges over laterals, and various necessary shipping facilities such as wharves, bulkheads, and piers (Board of Commissioners of the Port of New Orleans 1922a:181-188). In addition, the board created the position of business agent for the canal. As the following list of duties indicates, the individual in this post was responsible for helping to implement Mr. Coleman's recommendations, advertise the canal, locate companies to rent properties, and negotiate leases. The business agent was:

- 1. To find tenants for lots on Foundation site and carry on and consummate negotiations.
- 2. To encourage responsible parties to build laterals and sublaterals into industrial lands owned by them; to deal with them, and with those to whom they sell and lease, as may be necessary.
- 3. To represent on behalf of the Board, both by advertising and otherwise, the advantages of the Canal, from an industrial point of view, both on lands offered by the Board to industries, and on privately owned land on laterals.
- 4. To encourage by study and appropriate action, water-borne traffic on the Canal, particularly coastwise and other traffic, at present nonexistent.
- 5. To study the Canal to the sea right of way, question with purchase of right of way, in view as soon is the engineers have prepared alternate plans of routes, and to acquire a site when the Board desires it.
- 6. To work out a policy for industries and for

commerce based on instructions set forth by the Board and the General Manager, in region beyond the L and N Railroad.

7. To constantly study the whole relation of the canal to industry, navigation and commerce, and to make recommendations from time to time, as may be necessary to the General Manager, in order to secure the wisest use of the Canal (Board of Commissioners of the Port of New Orleans 1922b:178).

The canal was constructed in an undeveloped area consisting mostly of swamp and marsh land (Dabney 1921:20). Figures 50 and 51 are views of the river end of the canal at the time of construction. The large structure in the right background of Figure 50, taken at the time of canal construction, shows the Army Supply Center, one of three facilities constructed along the canal prior to its completion. The other two facilities were the Foundation and the Doullut and Williams Shipyards. Other than the Army Supply Center, the photos show few buildings adjacent to the canal. The typical swampland encountered in the middle section of the canal can be seen in Figures 52 and 53.

Six years after the canal was opened to boat traffic, only four facilities were established along the canal zone. These can be seen in air photos taken in 1929 (Figures 54 and 55). The Jones and Loughlin Steel Corporation, and the Lone Star Cement Corporation, were situated at the river end (Figure 54), on the west bank of the turning basin north of the Lock (Stiegman 1971a:77b). Continuing north on the west bank, was the Port Commission's Claiborne Avenue (Galvez Street) Wharf (Stiegman 1971a:77b). The only other facility was the Doullut and Williams Shipyard, located on the west bank, at the lake end of the canal. It can be seen in the foreground of Figure 55.

The Foundation Company Shipyard, which previously had leased land on the turning basin, shut down when government contracts stopped at the end of World War I. The company cancelled its lease May 8, 1922, one year before the canal officially opened (Stiegman 1971a:76). The Doullut and Williams Company managed to continue operations, but after reorganization in 1936, it renewed its lease for only three more years (Stiegman 1971a:76).

The Jones and Loughlin Steel Corporation and Lone Star Cement Corporation executed 99 year leases in 1923 and 1925, respectively. The properties rented included 9.91 acres by the Jones and Loughlin Steel Corporation, and 14.6 acres by Lone Star Cement (Stiegman 1971a:76). Other 99 year leases signed prior to 1940 include one for 15.75 acres with the Gulf, Mobile, and



Figure 50. Industrial Canal, prior to connection with the Mississippi River, looking south (Courtesy Board of Commissioners of the Port of New Orleans).



Figure 51. Tugboat "Samson" entering the Industrial Canal from the Mississippi River, February 6, 1923 (Courtesy Board of Commissioners of the Port of New Orleans).

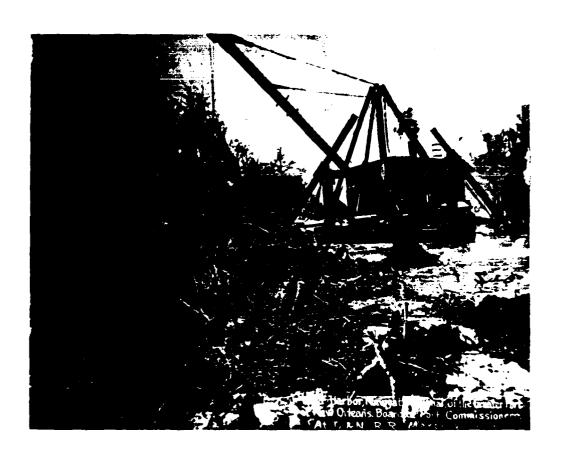


Figure 52. Dredging the central portion of the Industrial Canal (from Stiegman 1971:36).

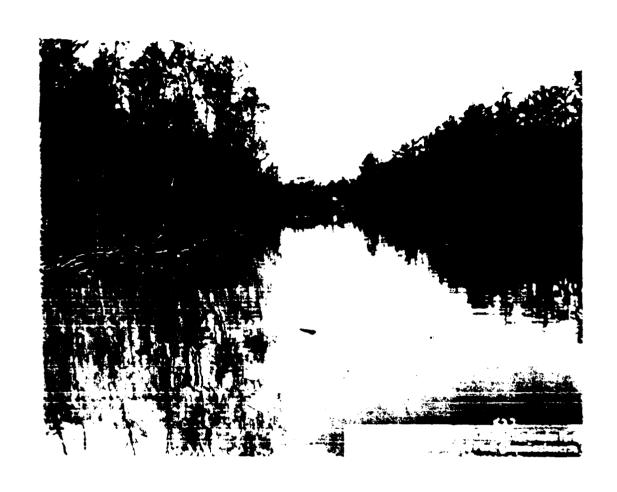


Figure 53. Typical swamp conditions encountered while dredging the center section of the Industrial Canal (from Stiegman 1971:37).

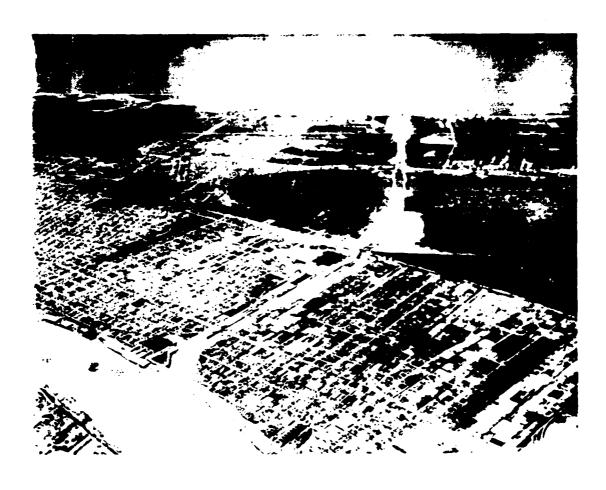


Figure 54. Aerial view of the Inner Harbor Navigation Canal from the south (Courtesy Board of Commissioners of the Port of New Orleans).



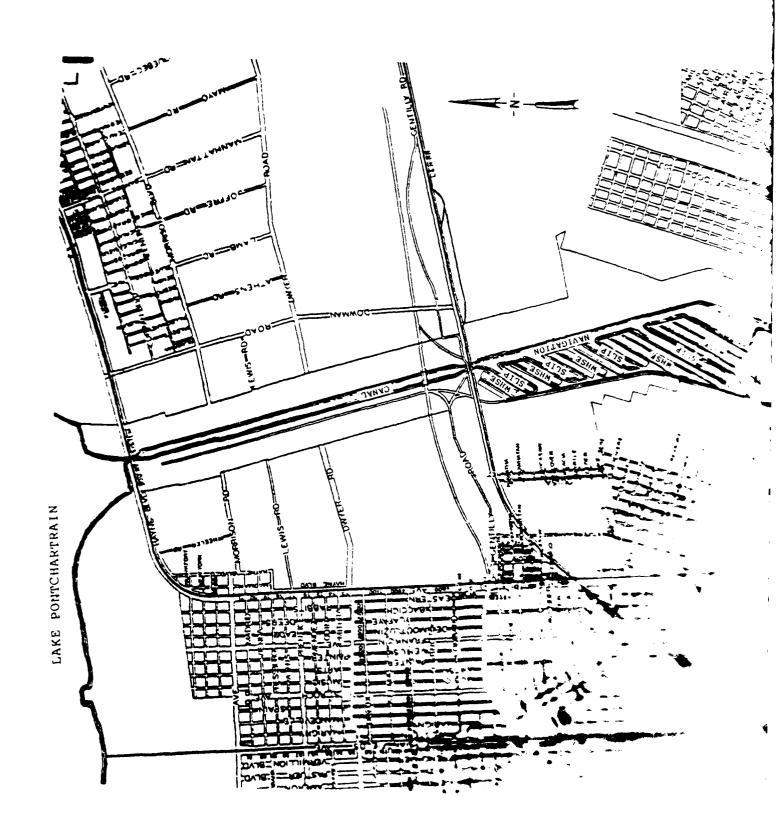
Figure 55. View of the Inner Harbor Navigation Canal from the north (from Stiegman 1971:136).

Northern Railroad in 1931; a small property adjacent to the rear of the lock leased by the U.S. Lighthouse Service in 1934; and, 14.2 acres leased by the Louisiana Materials Company (a shell supplier), in 1939. Two nine year leases were obtained by Lester F. Alexander for the purpose of turning the basin into a ship repair business. Also in 1939, two short term leases were signed by W. Horace Williams for three acres (Stiegman 1971a:76).

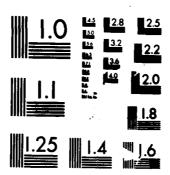
The paucity of lease commitments (eleven) over the 22-year period from 1918 to 1940, was due to economic, and to some extent, political factors. To begin with, the Dock Board was slow in instituting the recommendation for attracting industry, which Mr. Coleman had presented in 1922. As mentioned earlier, six years after the canal opened only one wharf facility at the end of Claiborne Avenue (Galvez Street) was available. No other docking facilities except those constructed by the lease occupants were in place. Practically no rail or road access routes had been constructed, and no utilities were in place on undeveloped land. Thus, no real progress had been made in implementing the suggestions under Mr. Coleman's category of "Incidental Construction Items." Furthermore, after six years there had been no construction of lateral canals as evidenced in Figures 54 and 55, and no progress had been made in planning for the proposed deep sea canal. By 1932, four laterals and accompanying docking facilities had been constructed on the west bank, north of the turning basin (Figure 56), however, little else was done until the beginning of World War II.

In addition to the lack of improvements, the Board of Commissioners apparently was asking for high rent fees that discouraged prospective leases. This problem, and the paucity of improvements, were identified in 1941 by incoming Board President, Lester F. Alexander, as the major barrier to canal growth. In a letter to the Board, dated October 9, 1941, he stated:

With the exception of the area on the West side between St. Claude Street Locks and Florida Walk Bridge, very little industrial use has been made of this tide water canal. The exact reason for this lack of development is not definitely known; the experiences obtained by this Board from its many discussions with prospective users of sites along the canal has led us to believe that the undeveloped condition of the lands owned by this Board along the banks of the canal, and the apparently excessive rental rates demanded by the Board, are the chief reasons for lack οf development. (Board Commissioners of the Port of New Orleans, Central Records 1941).



AD-A184 137 EVALUATION OF THE NATIONAL REGISTER ELIGIBILITY OF THE INNER HARBOR NAVIG. (U) GOODMIN (R CHRISTOPHER) AND ASSOCIATES INC. NEW ORLEANS LA F DOBNEY HER 137 15 JUN 37 COELMN PD-87/05 DACH29-86-D-0093 F G 13/2 4/4 NL . END PATE PILMED 9 87



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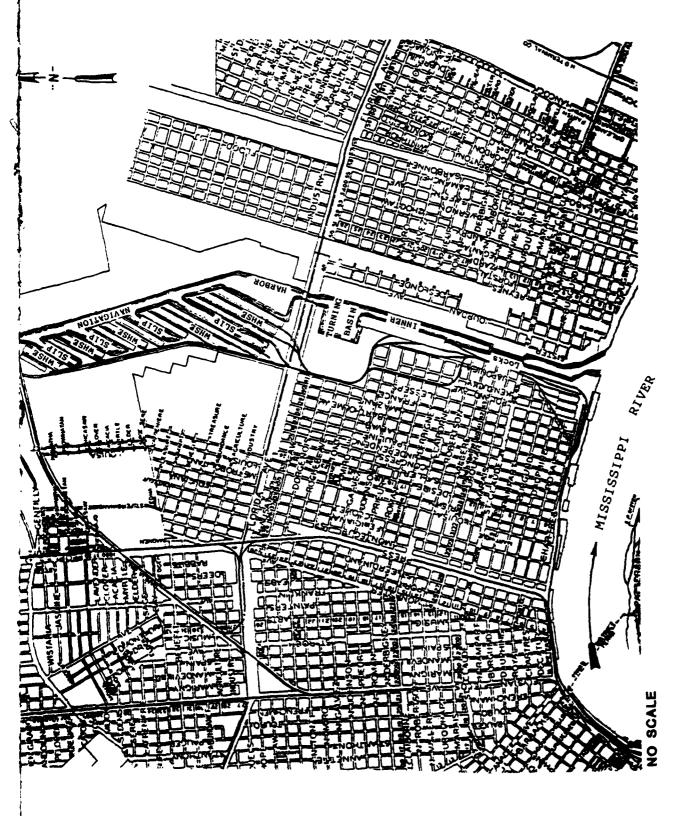


Figure 56. 1932 E. Harvey/West map showing the Inner Harbor Navigation Canal (Courtesy Historic New Orleans Collection).

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It is unclear why the Board did not reduce rental rates to attract more business. It may have been because of political considerations, or management deficiencies. It is clear, however, that their failure to make substantial improvements was due to prevailing economic conditions. With the costly canal newly opened and the country just coming out of an economic slump following World War I, little more was spent in improving the canal zone during the 1920s. Then, in 1929, the Great Depression began. Because of the depressed economy, the Dock Board lacked funds to make improvements to attract potential lessors. Even if the Board had been able to improve the canal property, few businesses were in a position to expand, nor were many new businesses being started.

By the 1940s, the situation changed dramatically. First, the country was coming out of the Great Depression. The economy was stimulated particularly with the onset of World War II. This encouraged both the growth of existing businesses and the establishment of new businesses. These changes, in turn, encouraged the Dock Board to implement planned improvements for promoting industry.

Another important change at this time was in the administration of the Port. Prior to the 1940s, positions on the Port Commission frequently were filled to reward political supporters, with little regard given for leadership capabilities. In 1940, a new system was set up for the appointment of Board members that sought to insure the selection of able leaders (see Stiegman 1971b).

On October 9, 1941, the first board established under this system convened. The President, Lester F. Alexander, indicated that it was his purpose,

... to get the members of the Board to begin to do some long term planning, to the end that the Port of New Orleans will not lose its standing in the post war days to come, but will be put in position to increase its world commerce (Alexander 1941).

At that time, planning for the St. Lawrence Seaway and the Tombigbee Canal in Alabama was underway. Both represented major competition to the Port of New Orleans. Therefore, action had to be taken to upgrade the Port. President Alexander proposed a resolution calling for an eighteen—oint plan to make improvements in the Industrial Canal Zone. Basically, the plan called for implementation of most of the improvements that the Board previously had been unable to institute or that they had neglected. In general, these involved a clean—up of the canal, enlargement of

water frontage, placement of public utilities, planning for land transportation (rail and highway), and an appropriation of \$50,000.00 for initiating the plan. The Board adopted this resolution.

Mr. Alexander proposed that the Port Commissioners also take the necessary steps to ensure the connection of the Gulf Intracoastal Waterway with the Industrial Canal, a plan that the Army Corps of Engineers had been authorized by Congress to undertake (Rivers and Harbors Act, July 23, 1942). The linking of these channels would result in an increase in commerce to the Port, and it would open a vast area of water frontage, providing a route for industrial expansion beyond the industrial canal. Furthermore, it was not unreasonable to assume that an outlet from the IHNC to the Gulf of Mexico eventually would be dug, promoting more commerce and industrial development. Because of its importance to the commercial and industrial development of the Port, Mr. Alexander wanted to be certain the project was carried to completion according to the design called for in the original Legislative Act. The Port Commissioner needed to work actively with the Corps of Engineers on this project.

Through the 1940s and 1950s, the majority of the improvements in Mr. Alexander's plan for the Industrial Canal were carried out, and the industrial canal was integrated with the Gulf Intracoastal Waterway. The effect of improvements in the canal, its linkage with the waterway, and an expanding economy, was the gradual increase in the development of the canal zone. Development also was aided in 1963 by the opening of the Mississippi River Gulf Outlet (Carlson 1983:32).

Available data indicate that significant industrial growth has occurred in the canal area since 1940. This is shown by the number of leases taken out during this period, and in the real estate maps for each year. Table 3 lists the leases executed between 1944 and 1965. Between 1944 and 1950, eight leases were signed; between 1951 and 1960, thirty-two leases were signed; and, between 1961 and 1965, nineteen leases were executed. These figures are a relative measure of the increasing movement of industry into the canal zone after 1940. They do not provide an accurate measure of absolute growth, since the counts are only for new leases. Some notion of absolute growth can be obtained, however, by comparing real estate maps. The maps in Figures 56, 57, 58, and 59 show lease occupancy in the canal zone during 1932, 1959, 1965, and 1983. The latter two maps also include lessors along the Gulf Intracoastal Waterway. The counts of 5, 55, 56, and 64, respectively, demonstrate that in terms of absolute growth, the industrial canal has been expanding.

While plans for development were available before the IHNC

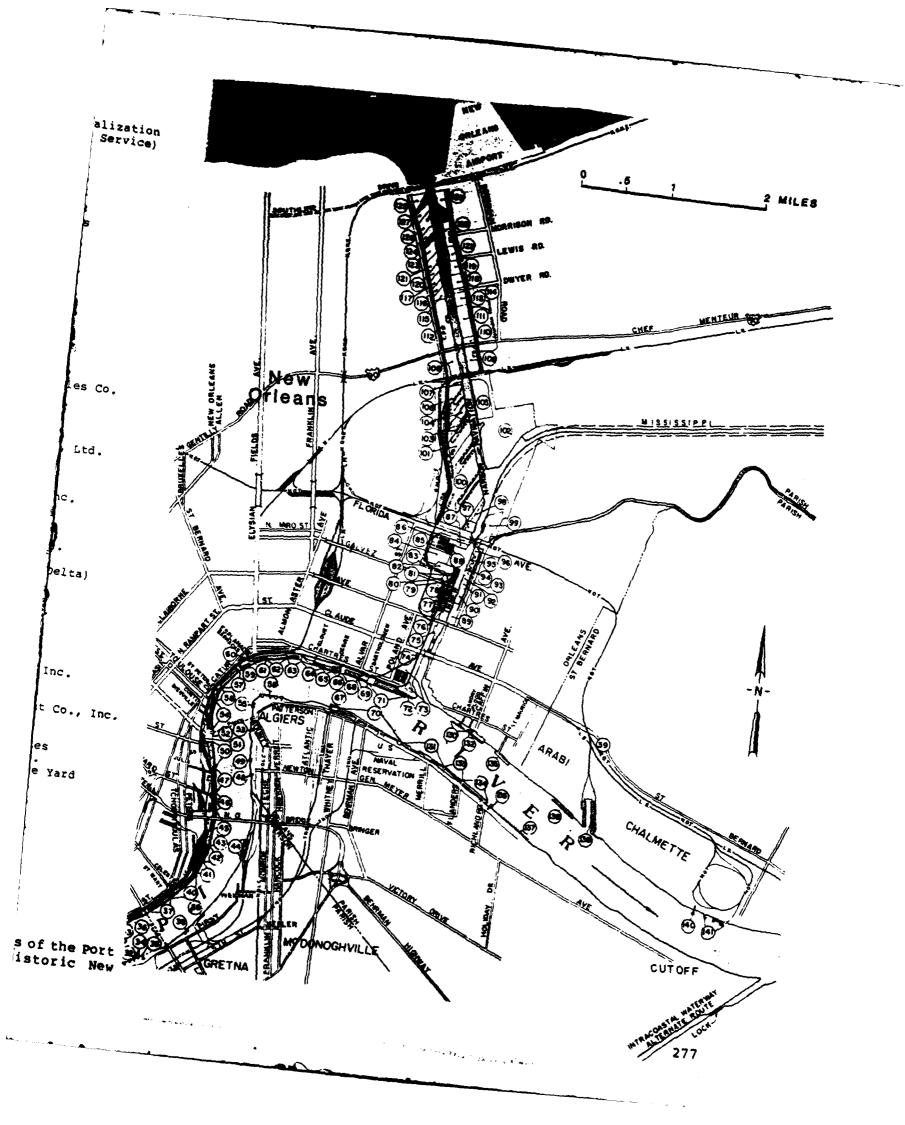
KEY

74 - U.S. Govt. Immigration Naturalization 75 - U.S. Coast Guard (Lighthouse Service) 76 - Harter-Vobel Contracting Co. 77 - Galvez Street Wharf 78 - Inland Waterways Corp. (Federal Barge Lines) 79 - Luckenbach Steamship Co. 80 - Flintkote Co. 81 - Bedell Structural Steel Works 82 - Jones & Laughlin Steel Corp. 83 - Schaller Steel Works, Inc. 84 - Lone Star Cement Co. 85 - Chase Bag Company 86 - Edwin H. Fitler, Co. 87 - American Marine Corp. 88 - Florida Avenue Wharf 89 - Site Available for Lease 90 - Saucer Marine Service, Inc. 91 - Canal Marine Repairs 92 - Indian Towing Co. 93 - McDonough Construction Co. 94 - Marine Welding, Scaling & Sales Co. 95 - Jourdan Avenue Wharf 96 - Boland Machine & Mfg. Co. 97 - Lone Star Cement Corp. 98 - Calmes Engineering Co. 99 - Southern Scrap Materials Co., Ltd. 101 - Southwest Steel Products 102 - Bethlehem Steel Company 103 - Bert Weaver Materials, Inc. 104 - Mechanical Equipment Co., Inc. 105 - American Marine Corp. 106 - Jahncke Service, Inc. 107 - Texas Bitulithic Co. 108 - Louisiana Materials Co., Inc. 109 - Standard Brands, Inc. 100 - Louisiana Shipyards, Inc. (Delta) 110 - Steel Service, Inc.
111 - Owens-Illinois Glass Co. 112 - Higgins Industries, Inc. 113 - N.O. Public Service Inc. 114 - Site Available for Lease 115 - Sand & Shells, Inc. 116 - Ideal Cement Co. 117 - Louisiana Concrete Product, Inc. 118 - Milwhite Mud Sales Co. 119 - Site Available for Lease 120 - Orleans Materials & Equipment Co., Inc. 121 - Laclede Steel Co. 122 - U.S. Gypsum Co. 123 - Williams-McWilliams Industries 124 - Boh Brothers Construction Co. 125 - Morrison Road Wharf & Storage Yard 126 - Magnet Cove Barium Corp. 127 - Standard Dredging Corp. 128 - Bay Towing & Dredging Co.

Figure 57. Excerpt of 1959 map, Board of Commissioners of the Port of New Orleans Facilities (Courtesy Historic New Orleans Collection).

129 - National Lead Co.

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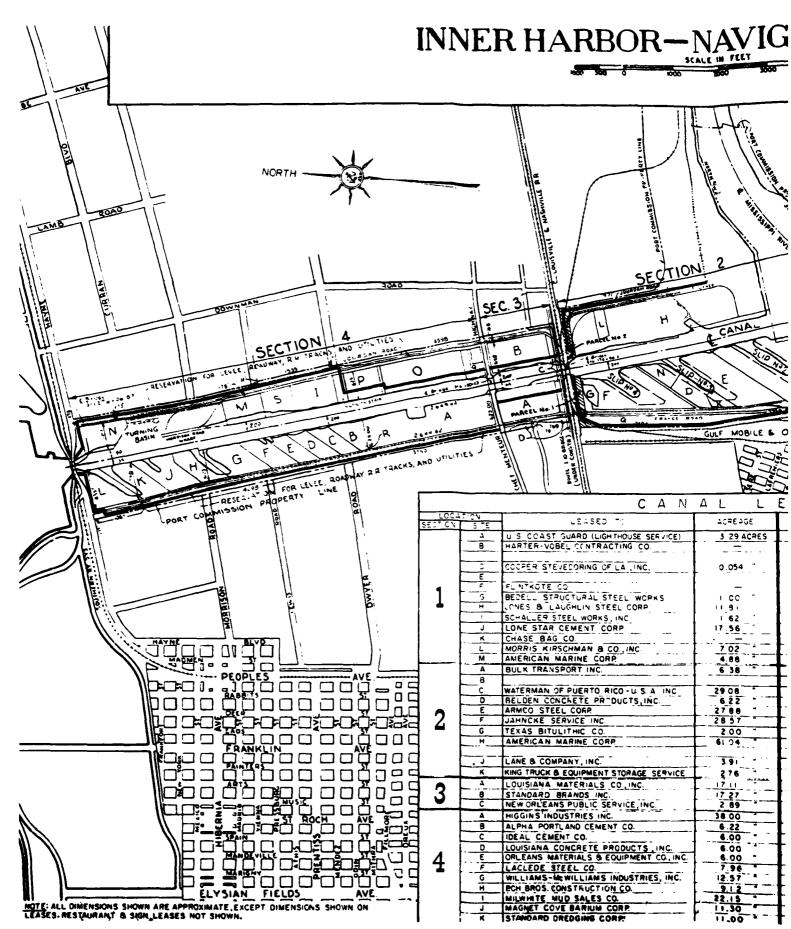
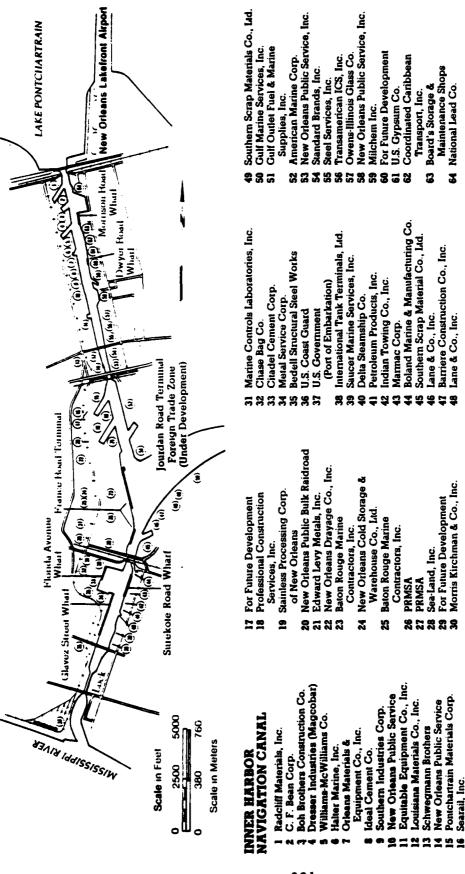


Figure 58. Overview of the Inner Harbor Navigation Canal zone, 1965 (map Courtesy Board of Commissioners of the Port of New Orleans).

VIGATION CANAL CANAL MAIN LEVEES CONCRETE LEVEE WALLS GULF MOBILE & OHIO RR S Ε 4195455 LEASED TO ACREAGE SOLAND MACHINE & MEG CO 3 29 ACPES MEDONOUGH CONSTRUCTION CO 2 054 CANAL MARINE REPAIRS 2.65 SAUCER MARINE SERVICE, NO (FE 8 52 1 9 MARINE CONTROLS CABORATORIES 52 9 56 SIMMONS PLATING CO 1.33 METAL CUTTING SPECIALTY CO, INC 7 02 4 68 GENERAL DYNAMICS CORP 6 38 LONE STAR CEWENT CORP 1 77 MECHANICAL EQUIPMENT COMPANY, INC 622 25 02 SOUTHERN SCRAP MATERIAL CO.LTD 39 SCHWEGMANN BROTHERS 17 27 2 89 38 00 RADCLIFF MATERIALS, INC 6 22 UNITED STATES GYPSUM CO 10 17 **0**0000 **0**0000 6 00 NATIONAL LEAD CO. 10 01 6 00 CHENS-ILLINOIS GLASS CO. 23 70 6 20 NEW ORLEANS PUBLIC SERVICE, INC. NEW ORLEANS PUBLIC SERVICE, INC. و تُقْ

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Overview of the Inner Harbor Navigation Canal zone, 1983 (map Courtesy Board of Commissioners of the Port of New Orleans). Figure 59.

Table 3. Leases on Inner Harbor-Navigation Canal, 1944-1965 (Stiegman 1971).

Date	Lessee	Side of Canal	Acres
03/17/44	U.S. Government - Lock	East & West	10.00
01/01/46	N. O. Public Service, Inc.	East	10.00
08/24/46	Flintkote Co.	West	0.45
06/21/48	Jahncke Service Co.	West	29.10
07/29/48	Jahncke Service Co.	West	1.47
07/01/50	U.S. Government Coast Guard	West	0.94
06/16/50	Ideal Cement Co.	West	6.00
12/08/50	Alpha Portland Cement Co.	West	6.22
02/22/51	La. Concrete Products, Inc.	West	6.00
04/16/51	Orleans Material & Equipment Co.	West	6.00
04/19/51	Laclede Steel Co.	West	7.96
04/24/51	Canal Marine Repairs, Inc.	East	2.65
05/15/51	McDonough Construction Co.	East	3.00
05/18/51	Schaller Steel Works, Inc.	West	1.62
07/19/51	Kirschman, Morris & Co., Inc.	West	9.40
05/02/52	Industrial Outdoor Displays, Inc.	West	N/A
06/26/52	Boh Bros. Construction Co.	West	9.12
07/29/52	Standard Dredging Corp.	West	11.00
08/07/52	Williams-McWilliams Ind., Inc.	West	12.57
11/18/52	Magnet Cove Barium Corp.	West	3.00
05/11/53	Boland Machine & Mfg. Co., Inc.	East	0.99
07/15/53	Standard Brands, Inc.	East	17.27
03/08/54	Bedell Structural Steel Works	West	1.00
04/12/54	Steel Service, INc.	East	6.00
05/01/54	Armco Steel Corp.	West	27.88
05/07/54	Industrial Outdoor Displays -		
	France Road	West	10.17
06/17/54	Indian Towing Co.	East	2.00
07/20/54	Belden Concrete Products, Inc.	West	6.22
12/27/54	United States Gypsum Co.	East	10.17
05/25/55	National Lead Co Bariod Div.	East	10.81
11/18/55	Mechanical Equipment Co., Inc.	West	5.34
11/22/55	N.O. Public Belt RR Commission	West	23.00
12/06/55	Lone Star Cement Corp.	West	3.77
12/16/55	Harter-Vobel Contracting Co., Inc.	West	N/A
03/07/57	Milchem, Inc.	East	22.15
03/14/57	Southern Scrap Material Co.	East	233
03/05/59	Owens-Illinois Glass Co.	East	23.70
12/15/59	Metal Cutting Specialty Co., Inc.	East	1.10
03/01/60	Federal Barge Lines, Inc.	East	7.07
12/21/60	Canal Marine Repairs, Inc.	East	0.37

Table 3, continued.

08/28/61	Southern Scrap Material Co., Ltd.	East	0.065
10/02/61	N.O. Public Service, Inc.	East	2.89
01/19/62	Southern Scrap Material Co., Ltd.	East	0.69
01/31/62	N.O. Public Service, Inc.	West	0.06
02/09/62	American Marine Corp.	East	41.48
03/26/62	King Truck & Equipment		
	Storage Service	West	2.76
04/11/62	Southern Scrap Material Co. Ltd.	East	1.10
07/11/162	U.S. Government Engineers-		
	Sites 5, 6, 7, 9	West	N/A
08/01/62	Radcliff Materials, Inc.	West	12.75
10/17/62	Industrial Outdoor Displays	West	N/A
03/12/63	Cooper Stevedoring of La., Inc.	West	0.054
06/20/63	Jones & Laughlin Steel Corp.	West	11.91
06/27/63	Simmond Plating & Metal		
	Finishing Co.	West	0.14
12/20/63	Federal Barge Lines, Inc.	East	1.45
05/01/64	American Marine Corp.	East	22.06
10/06/64	Boland Machine & Mfg. Co., Inc.	East	0.67
01/04/65	Metal Cutting Specialty Co., Inc.	East	0.863
01/08/65	Waterman of Puerto Rico-		
	U.S.A., Inc.	West	29.08
04/29/65	Bult Transport, Inc.	West	6.38
	-		

was constructed, none, including Coleman's, was followed in the early years. The first comprehensive plan, put forth in 1911, was for an "Industrial Basin." The map in Figure 10 illustrates layouts for laterals, sublaterals, and central docking areas.

In the 1930s, two proposals were made to organize "Industrial Districts." A proposal was made in 1930 by Mr. Walter Parker in which:

He advised the Port Commission that he had secured options, or certain properties adjoining the lands fronting the Industrial Canal; that he desired the right to lease the canal lands joining these land options, and to use the combined sites for commercial and industrial purposes will fall economic freedom: that he desired to open a navigable lateral into the leased land and into the private property and to build on the canal or lateral frontage, or both, wharves, terminals, warehouses, and any and all facilities required for handling of commerce and for the development of industry without restraint as to principals and without penalties (Stiegman 1971a:68-69).

The Board granted the rights requested, providing that the Board maintain its rights over leasing procedures, and over the establishment of laterals. Mr. Parker did not accept these terms, and the plan was dropped (Stiegman 1971a:69).

On November 9, 1937, the other plan for an Industrial District was presented to the Board. Mr. Samuel Zemurray made an offer to donate twelve to fifteen acres to the Dock Board in exchange for a right-of-way through his property for a lateral canal connecting his lands with the Industrial canal. Mr. Zemurray intended to use the construction of this lateral as an attraction to manufacturers, and to develop a small industrial area. Because Mr. Zemurray could not get prior commitments from industry, the proposal was deferred, (Stiegman 1971a:67-68), and then forgotten.

In 1959, further investigations into the possibility of an Industrial District were made by the Port Commission. A letter from the Port Director, Mr. Robert W. French, to the Port Planning Coordinator, Mr. William Lewis, dated January 16, 1959, indicated that tentative ir vestigations were being made into the possibility of an Industrial District,

... composed of that area lying east of the Inner Harbor Navigation Canal, south of U.S. Highway

90, west of Paris Road and north of Florida Avenue, (and its proposed extension). This would embrace areas lying both north and south of the Mississippi River Gulf Outlet, between the Inner Harbor Navigational Canal and Paris Road, and would include areas both in Orleans Parish, and St. Bernard Parish (French 1959).

Detailed plans evolved for placing industry in this area.

The most recent plan for an industrial district, the Almonaster-Michoud Industrial District (AMID), calls for 7,000 acres of industrial area along the Industrial Canal and Gulf Intracoastal Waterway (Figure 60). It includes services by various modern transportation facilities. Portions of the AMID plan currently are being implemented.

Additional studies of the Industrial Canal and of the connecting canal currently are underway, because the present lock has reached its carrying capacity. Traffic congestion and the inability of the present lock complex to handle large modern vessels have placed a limit on commerce in the industrial canal and adjoining waterways. The New Orleans District, Corps of Engineers, has been aware of the necessity for a larger lock complex to handle modern deep draft vessels and larger tows. Many different proposals have been made for a new lock with connecting channels (Figure 61).

The IHNC Lock Complex is a critical feature of the Industrial Canal, especially because it connects the Mississippi River with Lake Pontchartrain. For this reason, the lock is essential to the continued economic viability of the inner harbor area and of the industrial complexes within it. Because of its importance, the lock's administration and maintenance are major concerns to the Port.

Economic Growth

The impact of the Inner Harbor Navigational Canal and lock on the economic development of the Port of New Orleans can be assessed in terms of shipping and revenues which have occurred as a result of this project. In the following review, shipping data on the IHNC (tonnage, lockages, etc.) are presented and evaluated. In addition, revenue statistics are examined to elucidate the impact of the IHNC on the economic growth of the Port of New Orleans.

Table 4 presents statistics on ship traffic through the IHNC Lock during the period 1923 through 1985. These statistics show an erratic course in tonnage, number of vessels, and in lockages

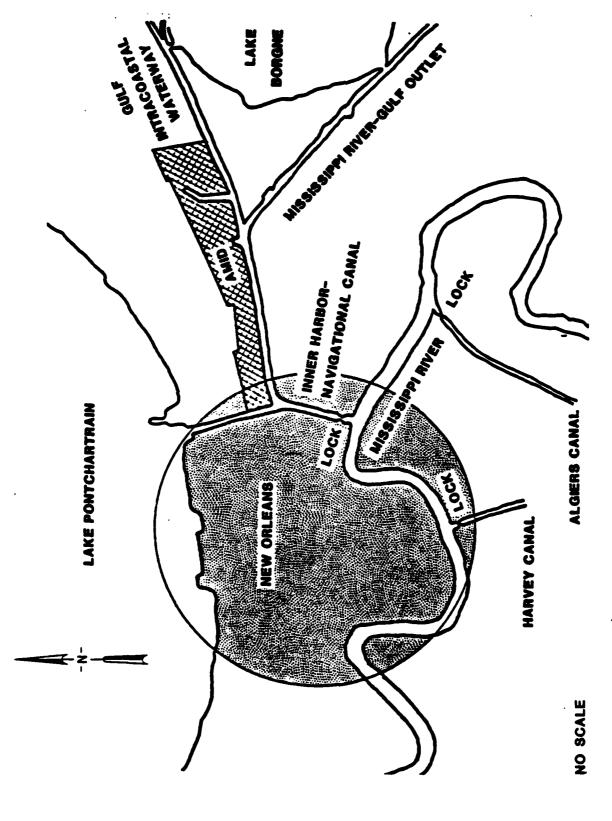


Figure 60. The Almonaster-Michoud Industrial District (AMID) and its relationship to the City of New Orleans (after Carlson 1983:33).

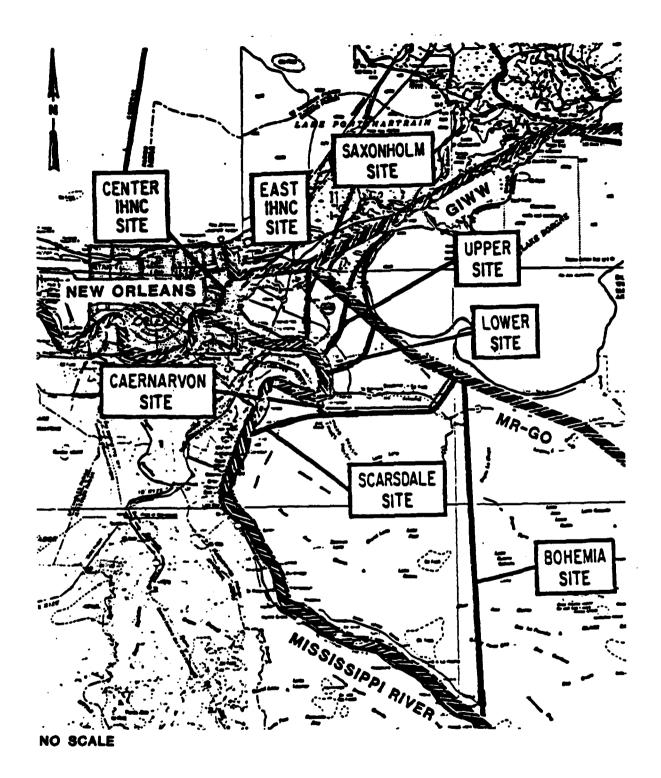


Figure 61. Seven alternative lock and connecting channel sites (after Corps of Engineers, New Orleans District 1975).

Table 4. Traffic by Year from 1923-1980, Inner Harbor Navigation Canal Lock (New Orleans District, U.S. Army Corps of Brgineers, Economics Department).

LOCKAGES	10,605	10,266	10,557	10,341	10,446	10,151	11,039	11,560	12,676	13,257	12,654	13,282	12,627	12,445	12,733	12,271	12,473	12,414	12,717	13,324	12,627	12,616	13,318	14,652	16,146	15,867	13,598	14,040	14,189
VESSELS	32,269	34,153	35,675	40,635	45,442	48,072	52,341	50,763	50,983	49,493	48,950	53,180	59,309	61,409	58,272	58,662	62,604	60,972	67,860	65,867	62,806	58,909	64,525	64,322	70,120	69,793	57,809	57,812	61,140
TONNAGE	000,008,9	6,630,000	7,461,000	3,388,000	9,588,000	10,661,000	11,075,000	11,619,000	12,064,000	11,805,000	11,259,000	12,683,000	14,215,000	16,819,000	17,609,000	17,900,000	20,645,000	19,887,000	21,805,000	23,650,000	23,832,000	23,408,000	26,232,000	25,478,000	28,151,000	29,469,000	23,825,000	23,776,000	22,338,000
YEAR	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1961	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
LOCKAGES	2	Z	1,869	3,026	3,409	4,205	4,417	5,535	909'9	5,587	6,957	2,996	5,985	5,855	6,184	6,356	6,468	6,774	7,350	7,558	7,312	¥	¥	8,925	9,040	8,748	9,368	9,639	10,316
VESSELS	£	Ź	3,620	5,589	5,708	6,487	7,460	7,311	10,150	9,440	11,324	13,332	12,566	13,451	14,491	15,499	16,194	17,079	19,705	21,986	24,319	13,426	10,682	24,284	26,471	24,865	25,813	28,048	30,612
TOWNSCE	Ź	Z	ó	2,919,000		3,655,000	3,959,000	3,351,000	4,006,000	3,601,000	4,471,000	5,353,000	2,595,000	5,151,000	5,625,000	5,902,000	2,905,000	6,081,000	7,040,000	7,509,000	8,950,000	2,388,000	1,430,000	3,852,000	4,445,000	4,005,000	4,405,000	5,055,000	5,587,000
Year	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951

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between 1925 and 1956. By 1956, a clear shift is evident towards a steady increase in these categories; this trend continued until 1977, when shipping business began to drop off again. These figures suggest that the mid-1950s were characterized by a pattern of steady growth in the volume of shipping through the canal. By 1956, the tonnage, vessels, and lockage figures had increased 50 to 100 per cent. Thus, by 1957 the IHNC had entered a significant period of growth in Port commerce. The drop in shipping traffic experienced after 1976 appears to have resulted from regional economic depression, rather than from a decrease in the canal's attractiveness to shipping.

The local significance of the IHNC can be illustrated by comparison with statistics for the Harvey lock for the same time period. As noted above, the Harvey lock is located on the west bank of the Mississippi River at the mouth of the Harvey Canal. the south is Bayou Barataria and the Gulf Intracoastal Waterway. The lockage, bottoms, and tonnage figures for the Harvey lock between 1968 and 1985 are shown in Table 5. While the lockage figures for the IHNC are greater during later years, there is a marked similarity in total lockages between Harvey and IHNC. In contrast, tonnage figures for the IHNC lock are commonly more than 100 per cent greater than those for the Harvey lock. This statistic is a result of the larger, heavier ocean craft that pass through the IHNC facility en route to the Mississippi River Gulf Outlet (MR-GO) and the Gulf of Mexico. Additionally, the greater tonnage at IHNC is a function of the successful development of the Industrial Canal and the MR-GO. Finally, the proximity of Lake Pontchartrain and of the Gulf Intracoastal Waterway serve to funnel shipping towards the IHNC.

These figures demonstrate that the IHNC has had a positive impact on the volume of commerce for the Port of New Orleans. In contrast, revenues from the IHNC have had either little or negative impact on the Port's economy. Revenues were obtained from the IHNC in two ways: user fees and rent from leases. Tariffs for lockages and use of the canal, as well as fees for mooring and docking, were included under user fees. Lease agreements with businesses and with the United States Government also provided substantial revenue for the Port of New Orleans. The 1944 agreement, which gave the Government the responsibility of management and jurisdiction over the lock and a section of the Industrial Canal, negated user fees from the locks; the canal became toll—free under the terms of that agreement.

Prior to the Government lease in 1944, revenues from the canal's operation did not contribute significantly to the Port's economy; this can be observed in Table 6, which lists expenses and revenues between 1923 and 1944 (the year the maintenance and jurisdiction of the lock and section of canal were turned over to

Table 5. Harvey Lock Statistics (Board of Commissioners of the Port of New Orleans).

CALENDAR YEAR	LOCKAGE	<u>s</u>	BOTTOM	<u>s</u>	TONNAGE	
1968 1969 1970 1971 1972+ 1973- 1974# 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990	13,737 13,567 12,671 13,182 9,001 12,964 11,122 10,178 11,616 11,757 12,202 13,133 12,528 12,253 10,754 10,246 9,960 9,210	(2) (1) (3) (4) (8) (2) (4) (4) (5) (4) (4) (5) (5) (5) (5)	37,104 36,624 32,172 34,390 23,516 37,776 32,512 28,583 29,716 29,380 33,340 39,738 31,279 28,824 24,955 23,794 22,821 19,885	(6) (6) (6) (6) (7) (7) (7) (6) (7) (6) (7) (9) (9) (9)	6,287,147 5,417,535 4,711,707 5,659,578 3,952,531 7,732,613 5,968,386 5,409,686 4,971,049 4,997,092 6,541,496 9,721,985 6,015,982 4,777,622 4,373,883 4,916,431 4,573,838 3,492,271	(8) (8) (9) (9) (8) (8) (9) (8) (8) (8) (8) (11)

 ¹⁹⁷³ high water forced the closure of various locks, and effected the normal flow of marine traffic on the Mississippi and Atchafalaya Rivers.

⁺ Dewatering year.

[#] Harvey lock damaged, lock closed for 20 days.

Table 6. Expenses and Revenues by Year at the Inner Harbor Navigation Canal, Shown in Thousands of Dollars (Stiegman 1971).

	(B) - (A) Surplus	¢,	-34	89	-102	-34	-49	-21	-13	-18	-30	-87	-12	13	24	11	&	54	82	110	187	320	446	631
REVIEWUES	(B) Total	¢2	933	995	1,024	1,116	1,135	1,138	1,151	1,134	1,125	934	1,122	1,119	1,122	1,121	1,152	1,169	1,178	1,189	1,159	1,278	1,373	1,498
22	Misc.	Ś	926	086	1,004	1,093	1,108	1,114	1,124	1,112	1,104	916	1,106	1,096	1,103	1,099	1,120	1,121	1,129	1,127	1,060	1,109	1,149	1,273
	Earnings	Ø		15	70	23	3 6	25	27	22	21	18	16	23	81	23	32	48	49	62	66	169	224	225
	(A) Total	W	296	1,063	1,126	1,150	1,184	1,159	1,164	1,152	1,154	1,022	1,135	1,106	1,098	1,110	1,145	1,115	1,096	1,078	973	928	927	867
	General	v	*	*	*	*	*	*	1,025	1,014	1,007	846	1,001	978	963	946	926	933	911	895	846	820	96/	761
EXPENSES	Indirect	တ	· *	*	*	*	*	*	65	63	74	111	20	29	29	95	96	82	88	93	49	2	55	37
	Direct	S	• 🛊	*	*	*	*	*	79	75	73	65	64	89	9/	69	66	102	26	91	78	89	9/	69
	Year		1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944

*Only total amount given for the year - not broken down into categories.

U.S. Government). Table 6 also indicates that it was not until 1934 that there was a surplus in revenues (\$13,000.00) after expenses. By 1944, this surplus had increased to \$631,000.00. However, the impact of this increase on the economy of the port was negligible since the canal and locks still were costing the City of New Orleans \$975,000.00 annually through indirect taxes imposed to pay off the construction bonds floated to build the canal and lock.

After the lease agreement of 1944, the loss in user fees for the leased section was compensated by annual Government rental payments amounting to \$240,000.00 (Carlson 1983:26). In 1960, the bond debt finally was paid off. Unfortunately, by that time the Government's rental payments no longer covered the Port's expenses for major maintenance of the leased area; under the 1944 lease, the Port of New Orleans was responsible for maintenance costs which were not incurred as a result of Corps of Engineers negligence. The Dock Board finally received some relief from this deficit through a supplemental lease agreement in 1980. This agreement increased the Government's rent to \$1.2 million annually. However, the Board continued to lose money because of increasing maintenance costs for the leased area; this amounted to several million dollars per year. Finally, in 1986 the United States Government agreed to pay all costs, to purchased the IHNC lock, and to take full control of the leased area, relieving the Dock Board of what had become a substantial financial burden.

Despite the financial problems such facilities faced, it was well-recognized during the internal improvement projects of the nineteenth century, that these canals were public facilities whose value and contribution transcended the mere revenue they produced. The jobs, the taxes, and the economic "life" they brought to an area were as important as the direct income from user fees. In that regard, the Industrial Canal in New Orleans has far more defenders than detractors. One port historian described the IHNC as "one of the principal factors in the development of industrial New Orleans and the progress of the port" (Martinez 1955:47). Use of the canal generally has been high. In recent years, it has reached capacity. The obvious conclusion, then, is that the IHNC lock is both busy and important. The very discussion of enlargement or replacement of the lock in the canal assumes the value of the IHNC lock to the port and to commerce through the area.

As a canal, the importance of the IHNC was recognized in the very selection of the site for the founding of New Orleans. Bienville chose as the location for New Orleans the place where the lake and river were nearest each other. Although the dream of connecting the two was not realized until two hundred years later, the need for doing so grew during the intervening centuries. The value and importance of the IHNC as a canal increased tremendously with its inclusion in the Gulf Intracoastal Waterway, completed in

1944, and, more recently, with the 1966 opening of the Mississippi River-Gulf Outlet (MR-GO). Now, as never before, it is a part of a successful waterway system (Carter, ed. 1968:282). As such, it is difficult, if not impossible, to place a monetary value on its contribution. As a key element in a larger system, the IHNC and lock must be recognized as an important factor in the economic success of this system and the area it serves.

As an "inner harbor," a factor which contributed to the development of the IHNC during and shortly after World War I (Roberts 1946:322), the Industrial Canal perhaps was slower to realize the potential which its slack water and approximately eleven additional miles of waterfront brought to the Port of New Orleans. Politics and policies of port management, now greatly improved, figured importantly in this result. Most of the canal is now leased, and with the opening of the MR-GO and the construction of "Centerport, U.S.A." (Board of Commissioners, Port of New Orleans 1970:5), the Industrial Canal is achieving and expanding its potential as an "inner harbor". The Inner Harbor Navigation Canal and lock has and will continue to play a central role in the commercial and industrial development of the harbor and of the great waterway systems which are a part of the City of New Orleans.

CHAPTER X

IHNC LOCKS: MAINTENANCE AND MODIFICATIONS

This chapter contains an assessment of the physical structure of the IHNC. During the course of this project, site inspections were made, Corps of Engineers and Dock Board personnel were interviewed, and the lock maintenance records were examined in order to assess the current operating status of and record of modifications to the original complex.

Although the maintenance records are extensive, some gaps exist. For example, all of the records kept by the engineering staff of the Port of New Orleans at the Poydras Street Wharf were lost in a fire on November 17, 1925. Furthermore, daily logs kept by the Corps lockmaster are retained only for a period of three years. Most of the major repairs to the complex, however, are well documented. These repairs generally were made when the locks were dewatered. All dewaterings subsequent to the first in the early 1930s are fully documented; these records were used as a basis for the discussion of structural repairs.

Maintenance and Dewaterings

Routine maintenance procedures at the lock are outlined in the manual entitled Operation and Maintenance Manual: Inner Harbor Navigation Canal Lock and St. Claude Avenue Bridge, Louisiana, published by the Department of the Army, New Orleans District Corps of Engineers, New Orleans, Louisiana (1975b). This publication is the only known maintenance manual for the IHNC complex. The main purposes of the manual are to present a set of guidelines for the upkeep of the lock machinery, and to provide an inspection frequency chart for the entire complex. The inspection frequency chart is shown in Table 7.

Most of the original machinery still is operating. While some pieces of equipment occasionally break down or wear out, maintenance has kept most items in good working condition. Replacement parts for the lock machinery usually are fabricated from original drawings kept at the site or by using existing parts as a template.

Dewatering is a term used to describe the process of removing all of the water from the lock structure. This process takes place during periods of inspection and repairs. During dewatering, the pressure on the lock walls is unequal; if the pressure is great enough, the walls will tilt toward each other. For this reason, the walls are monitored carefully during dewatering. If movement

TABLE 7. Schedule of Maintenance for the IHNC Lock (New Orleans District, Corps of Engineers 1985).

General								
ITEM	DAILY	WEEKLY	MONTHLY	6 MONTHS	1 YEAR	S YEARS	10 YEARS	REMARKS
CHANNEL	×							
a. Dmbankment b. Timber Guide Walls c. Wood Dolphins d. Concrete Chamber	***							
GROUNDS								
400000000000000000000000000000000000000	,							
a. Buildings	×;							
b. Heating & Vent System c pining & Ualues	××							
	× ∶							
d. Electric Cables	×							
	κ ;							
	٠,							
y. Williams & Doors	< >							
מחיות מיים	< :							
1. Utainage	× >							
	« ;							
n. Flucks 1. Plumbing systems	4 ×							
FIRE PUMPS			×					
FIRE HYDRANTS			×					
FIRE HOSES			×					
FIRE PLAN & EMERGENCY INSTRUCTION			×					
WARNING & SAFETY SIGNS	×							
NAVIGATION AIDS	×							
RADIO EQUIPHENT	×							
SOUND POWERED TELEPHONE	×							
SURVEY								
					×			
b. Alignment c. Cross Chamber					×	×		During dewatering
Strut pin, slip joint and jaw pins.	*							

All bearings fitted with grease cup whether hand or anxion fact

oil lubricated.

AGMA 8			м	End locking latch bar.	
AGMA 6			×	Trunnion and link pin bearings. Grease cup and pressure gun fittings.	
Lubricate SAE 30	×			Electric motors (ring oiled)	
Lubricate SAE 30		×		Position indicator gear shafts and gears	
Lubricate SAE 30		Ħ		Positions Indicators	
AGHA 4		×	-	Gear	
Lubricated SAE 30			×	Limit switches.	
AGMA 6			×	All other bearings fitted with grease cups.	
AGMA 8			×	Rising stem nut, thrust roller bearings.	
AGHA 6			×	Rising stem nut pressure gun fighting.	
	ж			Gate machinery operating electric motors. (ring oiled)	
		×		Position indicators, bearings, and collector rings.	
		×		Bull wheel center pin and large bevel gear pin. Fed through oil cups on manifold.	
		×		Eye bar wall anchorage pins.	
			×	High speed gear and motor pinion,	
			×	Heavy slow moving gears.	
			н к	Position indicator gear shafts and gears. Limit switches, gear shafts, shaft screw, spring and pinions. Star wheels.	
			×	Crank gear link pin or swivel joint, oil lubricated.	
			×	All bearings fitted with grease cup whether hand or spring feed.	
During dewatering	×	ì	×	Strut pin, slip joint and jaw pins.	

TABLE 7, continued.

<u> 5 years</u> <u>10 years</u> <u>remarks</u>	Lubricated SAE 30	Oil SAE 40 Summer Oil SAE 30 Winter	0il SAE 10	Oil SAE 30	AGHA 6	AGHA 6	АСНА 6	AGHA 6	Lubricate SAE 30	AGMA 6	Lubricate SAE 30		Lubricate SAE 30
1 YEAR 5											×		
6 MONTHS 1													
HONTHLY										×			
WEEKLY		×	*	ĸ	×	×	×	×	×			*	*
DAILY	×												
ITEH	Latch rollers, connecting rods, shafts and pins of end locking machinery, oil lubricated, including bridge buffer cylinder, piston and piston rod.	Gasoline engine (auxilliary power. Crank case and other oiled bearings).	Air compressor grank case, its electric motor and other bearings.	Crossing gate motors and gate operating machinery.	Sprocket chains and arm bearings of gates.	All gears on the St. Claude Avenue bridge machinery.	Operating strut rack and pinions on both bridges.	All gears on the bridge machinery.	Limit switches and mechinical indicator shaft and bearings.	Bridge end locking motors grease cup fitted bearings.	Electric motors (ring oiled)	Control Switches Push Buttons and Lemps	Pump thrust bell

AGMA 6

		Lubricete SAE 30	AGHA 6	AGMA 6	Lubricate SAE 30	Lubricate SAE 30	SAE 30	Lubricate SAE 30	AGMA 4	AGNA 6	AGNA B	Lubricate SAE 30	AGHA 4	AGNA 4	Lubricate SAE 30	Lubricate SAE 30	Lubricate SAE 30		Change SAE 40	Change SAE 30	ACHA 6
)				*	×	м	×	H	н	×	×	*	м	M	w	×	н	м	N	M	×
	Control Switches Push Buttons and Lamps	Pump thrust ball k	Pump shaft and pump bearings.	Equalizing valves, crank gear stands and shaft bearings.	Semaphores, motor and other mechanism.	Position indicating devices in lock central house. Index motor.	Other parts oil lubricated.	Motor, thrust ball bearing and sleave bearings.	Wire rope	All bearings with grease cups and pressure gun fittings.	Heavy drive shaft bearing hoisting machinery.	Limit switches controllers and indicators.	Gears.	Turning pinion and tooth circular rack.	Unlatching device in ends of stop log girders.	Watertight cover	Crane Center pivot pin.	Watertight cover studs and bearing pads.	Hoisting motor beatings (ring oiled)	Turning motor bearings (ring oiled)	Stop log girders horizontal and wall bearings.

should occur, the lock would be refilled with water, the earth would be removed from behind the lock walls until the walls were stable, and the process would begin again. This emergency stabilization procedure has not been needed to date. Yet, it does underscore the serious nature of the dewatering process.

Dewatering is known to have occurred during the early 1930s and in 1948, 1952, 1953, 1954, 1965, 1978, and 1983. The next scheduled dewatering is in 1990 (IHNC Periodic Inspection Report #5). In the most recent Corps report (July, 1983, revised 1984), it was concluded that the IHNC Lock was "safe, stable, and in satisfactory operating condition" (IHNC Periodic Inspection Report #5). However, several remedial actions were proposed, including:

- a. Concrete spalls revealing exposed reinforcing steel in areas of the lock chamber where repair work would hinder lock operations to be cleaned and repaired during the second quarter of FY 84.
- b. Replacement of machinery room concrete hatch covers with new grating.
- c. Leaking water pipe to be fixed to prevent water spillage into the machinery room for miter gate 10. Correct water seepage from the floor. Construction joint and concrete repairs to be made to the bottom step and column.
- d. Repairs to be made to the joint material that separated from the concrete, allowing water to pass through the joint on the river end at the junction of the north tunnel and the machinery room.
- e. Cracks on the top of the lock wall to be resealed.
- f. Damaged and/or missing timber bumpers from the chamber faces of the miter gates to be replaced.
- g. Gate leaves 5 and 6 to be painted and repaired.
- h. Gate leaves 7 and 8 to be repaired to correct leakage.

With regard to the machinery and the control equipment, the report

by the Corps stated that the lock operating machinery was in satisfactory condition. A spot check of the fire protection system showed that the hoses were in good condition and that there was sufficient water pressure. At the time of the inspection, however, the dewatering pump and both fire pumps were inoperative due to faulty electric wires; this condition was rectified immediately.

The emergency dam crane operated satisfactorily during this inspection; however, due to the time factor and to the potential for navigation delay, the bulkheads were not lifted and swung into position for installation. The lockmaster stated that the machinery was tested satisfactorily the previous month by lifting and swinging a bulkhead into position for installation.

At the time of the inspection, gate leaves 7 and 8 did not seal properly (see item "h" above). The gate bay at this location was dewatered by Operations Division personnel during August, 1983, and repairs were made to correct the leakage. Repairs consisted of dewatering the gate bay area and adjusting the vertical timber seals on the miter end of the gates in the dry so that a proper seal could be made.

In addition to the specific repairs outlined above, other maintenance efforts are performed as needed. For example, timber guidewalls and bumpers require regular maintenance. These items are constantly bumped by vessels moving through the IHNC; therefore, they are worn quickly. Another regular maintenance item is the finish on metal components. The lock gates, emergency dam crane, girders, and machinery are sandblasted and painted when surface corrosion appears.

Very little settlement of the lock embankments has occurred. Settlement is the term used to describe a condition where the earth is eroded by an underground source of water. The effect of this type of erosion would be that the pressure on the sidewalls of the lock structure would be uneven and the weight of the water would push the walls outward until a new equilibrium was reached. One serious sinkhole has been reported at the site. However, Corps personnel feel that the settlement probably was caused by existing water and sewer mains in the area. No new settlement has been reported since the hole has been filled and the mains have been checked.

Accidents and Subsequent Damages

During the period from November, 1944, through April, 1972, eleven accidents resulting in damage to the IHNC complex were documented. Minor damage to lock gate 7 was incurred by the

collision of an LST on November 11, 1944, requiring welding and riveting repairs. Six pile dolphins were damaged by tugs between January 31 and March 1, 1949, also of apparently little consequence. Two accidents occurred during the dewatering process in 1952. The first, on July 30th, was described as fairly serious: the emergency dam cable broke while preparing the locks for dewatering. The 92-ton stop log with a 15-ton hook block dropped into the lock chamber, resulting in \$20,000.00 of damages. On August 14th, vent plugs installed during dewatering blew out when a culvert was pressurized. This accident apparently was due to a fracture two to four inches in width across the bottom of the locks and up the lock wall between the lock and the culverts at the Serious damage to the Florida recess of miter gates 5 and 6. Avenue bridge occurred on March 18, 1967, when the M/V Southern Star collided with the dolphins.

M/V GALAXY FAITH

On April 4, 1972, at 9:30 p.m., the M/V Galaxy Faith ran into the gates at the south end of the lock, damaging gate 1 and knocking gate 2 completely off its hinges. A survey team located gate 2 in the middle of the lock chamber, about 325 feet north of its normal hinged position.

The team reported the bottom hinge pintle for both gates 1 and 2 was in satisfactory condition, but the bottom lock sill for gates 1 and 2 was damaged. When the Galaxy Faith hit gate 2, it not only knocked it off its hinges, breaking both the turnbuckle and operating arm, but it also bent the ten inch pin in the bull gear that operates the arm and gate. A cost-plus fixed fee construction contract was negotiated with Lane and Company, Inc., to repair gates 1 and 2 and place them back in operation. The total cost of these repairs was \$211,500.00.

The following were the major items required in the repair of gate 2: clean, dewater, and air test; repair top hinge plates; check gate alignment; repair clapping sill; repair six feet of miter timber at top of gate; repair five feet of seal timber at bottom of gate; repair control arm hinge pin anchor casting; repair three fractures in gate plating; and, make many small repairs of steel and timber. The following items of repair work were accomplished by Lane and Company, Inc. after gates 1 and 2 were repaired and the locks were returned to normal working operations, between April 24 and June 9, 1972:

a. Repaired damaged concrete at upper hinge of gate 2; at upper hinge of gate 1; at machinery room roof of gate 2; at lockwall, east and west sides; and, at sidewall adjacent to stop log

storage racks.

- b. Repaired stop log no. 4.
- c. Clean, grease, and paint all eight stop logs.
- d. Moved stop logs nos. 7 and 8 from cargo barge to lock storage racks for stoplogs.
- e. Rebuilt gate 2 broken turnbuckle and returned to storage at lock to replace the turnbuckle taken from storage for use of gate 2.
- f. Rebuild lock stop log crane by welding on and painting the stop log guides that had been cut off by others prior to this contract.
- g. Repair greenheart timber miter sill on gate no. 1 (Reports Control Symbol LMNCD-C-1 Contract DACW29-72-C-0141).

Following the Galaxy Faith incident, records become more copious and the number of accidents too numerous to report. It should be noted, however, that no serious accidents have occurred since the Galaxy Faith incident.

Modifications to the Original Design

The only item of equipment that has been redesigned is the control panel system. This process officially began in November, 1959. A letter from Colonel G.M. Cookson, C.E., New Orleans District Engineer, was sent to the Board of Commissioners, Port of New Orleans, detailing the modifications to be made to the control system.

The major alteration was the installation of control panels and panel housing on the south and north ends of the lock west wall, with the connection of the Selsyn circuits into the control system. Using the control panels on the lock wall, one person could operate the lock gates and valves from the panels; the bridge operator could be stationed in the bridge house at all times. This method substantially reduced locking time, especially during low water periods. The new controls were put into service by June, 1960. By September, 1962, another letter was written from the Corps to the Board of Commissioners (File No. LMNKL), requesting the replacement of two control panels for valves and gates at the locks. It also was suggested in this letter that all eighteen control panels be replaced. By September, 1965, six of the

eighteen panels were replaced, and the Corps requested the replacement of the remaining twelve panels at a rate of three per year during the next four years (U.S. Government Correspondence Folder ‡7, Board of Commissioners, Port of New Orleans, Central Records Archives).

Outstanding Features of the Original Design

The IHNC lock structure and equipment have performed well over the years. The isolation of specific items for discussion is difficult; however, the design of the emergency dam and the design of the gate equipment are outstanding.

The dam components were discussed in Chapter VIII. Large slots were built into the north and south ends of the lock walls. A series of steel stoplogs is placed into the slots, one upon another, to form the dam. The idea is simple, and it is representative of how very complex problems can be solved with clear thought. When originally designed, the dam system was innovative. Today, most lock structures have similar dams. With the exception of the gantry crane, the system has functioned extremely well.

The gate equipment was discussed previously. This equipment has performed well for 65 years, and it might continue to operate for another 65 years if well maintained. Unlike modern equipment of the same type, the original motors and gears were designed to exceed their normal operating limits. It is interesting to note that if this equipment was proposed for a similar use today, it probably would be rejected because it would not be considered economical. Yet, one must always evaluate the longevity of a product as well as its cost.

Deficiencies of the Original Design

Most of the originally designed machinery and equipment of the IHNC lock system is in good working order with the exception of the Gantry crane or emergency dam crane. The crane problems were outlined in a letter dated December 6, 1972, from Col. Richard L. Hunt, C.E., District Engineer, to John B. Giddens, Jr., Chief Engineer, Board of Commissioners, Port of New Orleans (LMNOD-NL). The Corps of Engineers' primary concern was the reliability of the latching mechanism. The Corps felt that the risk of failure of the hooks to disengage or engage was too great to depend upon the crane in emergency situations during which conditions or timing might not be ideal. Despite these objections, the Gantry crane has been maintained and it is still in service. Routine trial runs were recommended in Col. Hunt's letter of 1972, and these have been

performed as indicated in the dewatering report of July 1983.

A second condition which may represent a deficiency in the original design is the occurrence of spalling. Concrete spalling is a term used to describe a condition that exists when a portion of concrete separates from the main mass. This condition can be caused by the freezing and thawing process, by direct impact, by the placing of the steel reinforcement too close to the edge of the concrete, and by differential movement of two concrete masses.

No spalling due to the freezing and thawing process has been reported at the site. However, direct impact spalling has occurred. This condition exists along the top edge of the lock walls; it probably was caused by vessels bumping into the walls. While damage to the structure has occurred, it is minor. This condition can be repaired by sealing or by patching the exposed area.

A more serious problem occurs when reinforcement is placed too close to the edge of the concrete. Concrete is a brittle material, and the strength of the concrete under normal wear is directly proportional to its thickness. By placing the reinforcement close to the surface of the concrete, a weak spot is created. Under normal wear, or by expansion and contraction of the reinforcement, the concrete spalls. This condition is prevalent throughout the site. Upon visual inspection, it was found that the reinforcement has deteriorated where spalling has occurred. It also was noted that the reinforcement is exposed in places where no spalling has occurred. This type of spalling can be attributed to improper placement of the reinforcement and to poor inspection policies when the structure was built. Figure 62 illustrates the problems that were associated with the placement of the steel.

If the spalling is not checked, both the concrete and the reinforcement will continue to erode. Yet, efforts to repair spalls are largely ineffective. New concrete does not adhere well to old concrete. Furthermore, new concrete generally is not placed in a thickness required to hold up under normal wear. Proper patching techniques are expensive and have only been applied in vital areas.

Spalling caused by differential movement of the concrete mass is rare. Although several locations where this condition exists have been noted, there is no evidence that the structure has actually split apart. It seems more likely that the spalling was caused by expansion and contraction at natural joints in the concrete.

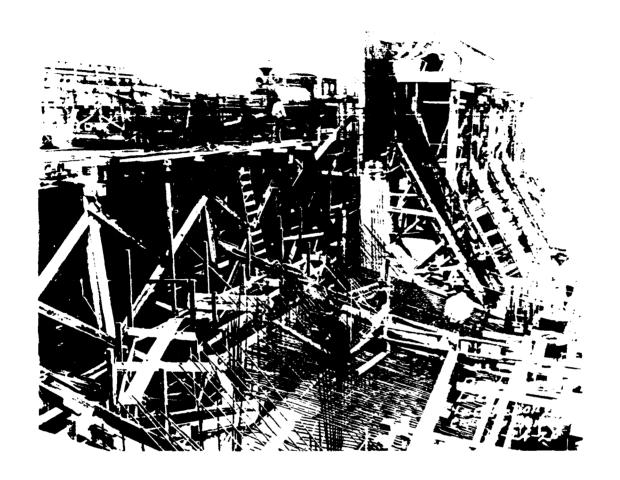


Figure 62. The placement of reinforcing steel during the construction of the IHNC lock chamber in December of 1920 (Courtesy Board of Commissioners of the Port of New Orleans).

Seepage

The most significant structural problem at the site is the seepage of water through cracks in the lock. The lock was built as a monolithic structure. No expansion joints were provided that would allow the lock to change size as it heated or cooled. The reasoning behind this decision is not known, yet several explanations are possible. It seems likely that concrete construction technology had not advanced to the point that the design team knew the effects of not using an expansion system. Alternatively, the designers may have felt that an expansion joint system was not necessary.

However, they did recognize the fact that the concrete would crack. Construction joints were placed in the outside face of the lock walls. These joints are a "v" in section, and are placed in the concrete so that the joint pattern appears as a series of large interlocking blocks. Cracks were supposed to occur in the block pattern. This is not the pattern that the cracks formed. The cracks appear as straight lines that ring the entire lock structure. A thorough examination of the cracks was made in 1978. Figure 63 includes those cracks where seepage was found to occur.

The areas where water seepage is occurring represent a real danger to the lock structure. For seepage to be present, the concrete must be cracked through its entire thickness. The water passing through the cracks is eroding not only the concrete, but also the reinforcing steel. If the steel fails, it is likely that differential settlement will take place, the cracks will widen, the tunnels and machine rooms will fill with water, and the IHNC structure will be useless.

It is likely that many of the cracks were formed during the period when the concrete was curing, since concrete shrinks as it hardens. This supposition is further supported by reviewing old photographs (see Figure 64). Dark streaks in the lock walls coincide with typical crack formations. Thus, the omission of expansion joints must be considered a design flaw.

Efforts to control seepage have met with some success. In the 1983 Corps report on the lock wall, it was noted that the material used in 1976 to patch the top of the lockwall (Sikaflex 1A) was holding up well, with some exceptions (IHNC Inspection Report #5). The satisfactory performance of Sikaflex 1A was attributed to properly routing and cleaning the surface on which it was placed. Wider patches were not in as good condition as the narrower ones; this probably was due to improper preparation of the wider cracks. In the report, Sikaflex 1A was recommended for future repair work due to its flexibility (400% elongation) and proven performance. As long as the seepage control is continued,

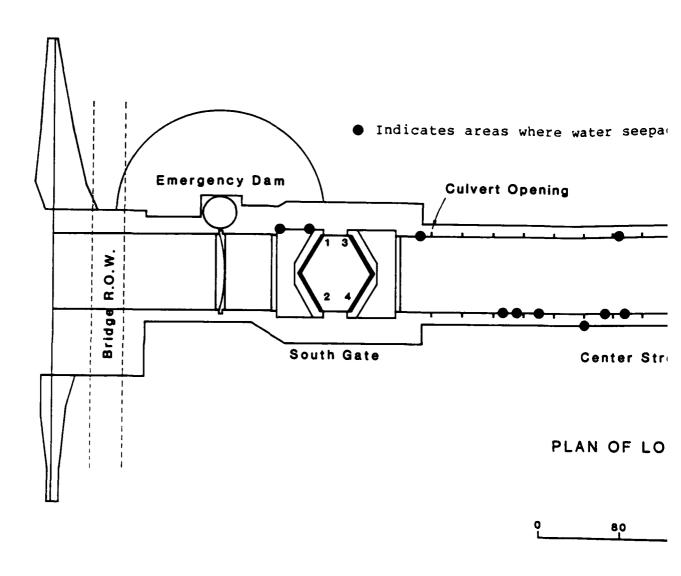
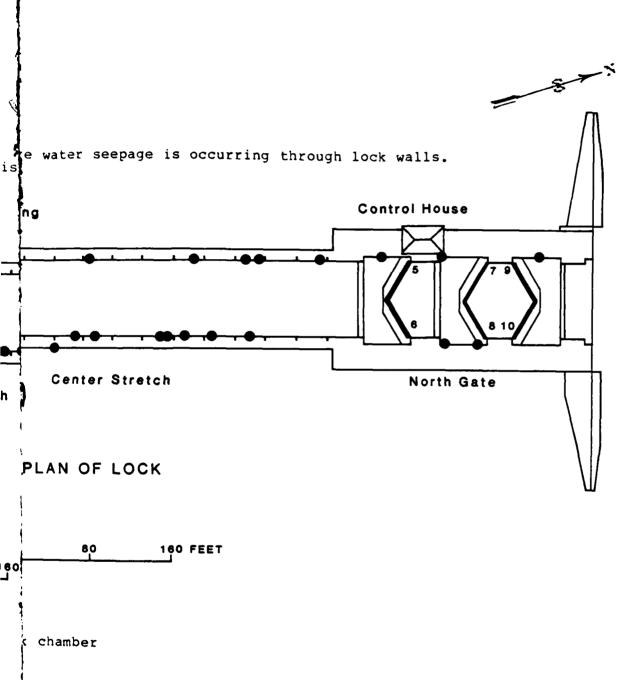


Figure 63. Points where seepage occurs in the IHNC lock chamber (represented by circles on the plan).



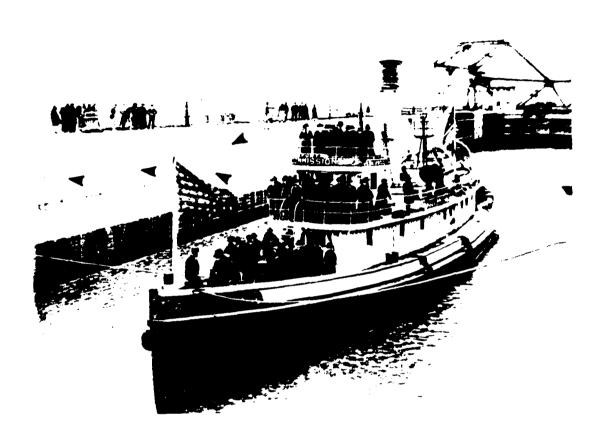


Figure 64. Tugboat "Sampson" in the IHNC lock, February 6, 1923.
Note the cracks in the lock wall (Courtesy Board of Commissioners of the Port of New Orleans).

the IHNC lock structure should remain in satisfactory operating condition.

The final deficiency of the design was the failure to anticipate an increase in vessel size. The locks, when first designed and operated, could accommodate the ship traffic of the times. Since then the size of ships and the length of barges has increased tremendously. The locks are now a barrier to large waterborne vessels.

Critical Assessment

Inspection of the plans for the original design of the IHNC lock, review of subsequent modifications to the structure, and the maintenance records of the last sixty plus years all indicate that the IHNC lock possesses historical integrity. The original arrangement and operation of the various components include the miter gates, the gate operating machinery, the sluice valves and machines, and the emergency dam system. The fact that the lock chamber has retained its structural integrity further illustrates the success of the original design. In general, then, it may be concluded that the IHNC retains both its original character, and that its modus operandi remains fundamentally unchanged.

Barring natural disaster, accident, or a reversal of current maintenance practices, the locks could operate for another 50 years or longer. Although maintenance costs will increase as time passes, these costs will be far less than the initial cost of the locks or the cost of new locks. One can only agree with the Corps personnel who are responsible for lock maintenance: the lock is safe, stable and in satisfactory operating condition.

CHAPTER XI

CONCLUSIONS AND RECOMMENDATIONS

This final chapter is an evaluatory assessment of the National Register eligibility of the IHNC lock using the information, context, and comparisons presented above. This section begins with a brief recapitulation of the historical themes or patterns salient to this National Register assessment. In the case of the Industrial Canal locks, several recognized themes apply under two of the established National Register criteria (36 CFR 60.4).

As noted in Chapter I, the research phase of this project was designed to develop a thematic context for assessment of the significance of the IHNC lock. Then, by examining the IHNC lock first-hand and by researching similar contemporary structures, it was possible both to assess its integrity and to compile a list of characteristics that would make the IHNC lock a significant representation of the previously identified themes.

The IHNC lock also was assessed in terms of its significance on the local, state, and national levels. Finally, the integrity of the lock, and of its constituent parts, were examined and evaluated in detail. The following text is organized so that the linear decision-making process leading to the National Register assessment is clear. Following the assessment of potential significance, mitigation alternatives are discussed.

Classification

This National Register assessment is specific to the Inner Harbor Navigation Canal <u>lock</u>, which was completed in 1921. Following definitions established for the National Register, the lock is viewed as a <u>structure</u>. According to the Secretary of Interior's guidelines entitled "How to Apply the National Register Criteria," a structure is defined as:

... a work made up of interdependent and interrelated parts in a definite pattern of organization. Generally constructed by man, it is often an engineering project.

As a structure, the IHNC lock must satisfy established criteria to be considered a significant exemplar of its related themes and type. This requires that all important or significant structural elements possess a high level of integrity in terms of design, workmanship, and materials. In addition, the regulations require

that the IHNC lock be viewed as a <u>single</u> complex made up of many component parts, i.e., the individual parts of the structure cannot be considered for National Register inclusion.

Historical Themes

The establishment of a proper historical context involves the definition of relevant time periods and geographic area. In addition, significant historical themes must be demonstrated, through scholarly research, to be of importance within the broad patterns of American history. The previous chapters presented many recognized historical themes. These themes or patterns comprise a series of events that have influenced historical development within a specific area (local, state, or national), or in a scientific discipline (mechanical, structural, and hydraulic engineering). This influence may have come from a single event, or from a series of events that may be interpreted as a developmental force. In addition, the significance of a property may stem from an association with the life of a person proven to be important or influential in American history.

The IHNC lock possesses the quality of significance on a national level within the established themes of American engineering and technology, maritime history, and national defense. On state and local levels, themes such as commerce, community planning and development, economics, industry, and politics/government are relevant. The construction of the IHNC lock cannot be divorced from that of the Industrial Canal; one would have been impossible without the other. Therefore, the impacts of the canal on the City of New Orleans are an integral part of the National Register assessment of the lock complex. The following components of this assessment present each relevant theme, and substantiate more themes with reference to pertinent chapters of this report. Following the discussion of historical themes, the assessment of the IHNC lock in terms of criteria A, B, C, and D (36 CFR 60.4) is concluded.

Politics/Government/Community Planning and Development

Locally, the construction of the Inner Harbor Navigation Canal (IHNC) and lock represents a series of significant decisions made by the citizens of New Orleans and their elected and appointed officials. The need to improve local shipping was spurred by a period of economic uncertainty following the Civil War. Chapter III of this report illustrated various historic accounts of local projects which attempted to improve navigation. The IHNC represents the culmination of years of debate over finding both an optimum location for a canal, and the means for the necessary funding (Chapter IV). A key point is that the project eventually

was funded, through bond issue, by the citizens of the City of New Orleans. The IHNC project, then, represents planning by New Orleanians, and a well-founded attempt to revitalize New Orleans as an international port. In addition, the construction of the Inner Harbor Navigation Canal provided the city with a new industrial corridor for development. A critical assessment of the success of this project was contained in Chapter IX of this report. The results of research show that the City of New Orleans still benefits economically from the IHNC project. Thus, the construction of both the Industrial Canal and the IHNC lock are related directly to the locally significant theme of urban planning and development.

Commerce/Economics/Industry

Chapter IX of this report illustrates the impact of the IHNC on the national and international prominence of the Port of New Orleans. This chapter presented lockage, tonnage, and shipping statistics integral to the assessment of the nature (positive and negative) of economic impacts that the construction of the Industrial Canal and lock had on the economy of the Port of New Orleans. These statistics indicate that the construction and subsequent opening of the IHNC were characterized by a marked increase in the interchange of goods, wares, and agricultural products handled by the Port of New Orleans. Any products which make their way through the city via shipping translate into These revenues are collected in the form of tariffs, dollars. user fees, and rental agreements. In addition, the creation of the Industrial Canal corridor resulted in increased commercial and industrial growth in the City of New Orleans; several businesses actually were established along the banks of the canal before it officially was opened to navigation traffic in 1923. The subsequent development of the Industrial Canal corridor resulted not only in an increase in taxation and revenues, but in the creation of local jobs. Thus, the IHNC canal and lock were directly responsible for a specific economic, commercial, and industrial revitalization of the City of New Orleans, and of the state of Louisiana.

Engineering/Technology/Invention

Within the context of the history of mechanical, structural, and hydraulic engineering, the IHNC lock may be viewed as an important and influential structure. Many techniques used at the IHNC lock were initiated during the Panama Canal project; both projects are associated with the professional life of Major General George W. Goethals. Major General Goethals was responsible for assembling one of the most influential groups of engineers to accomplish the tremendous task of connecting the Atlantic and Pacific Oceans. Although Mr. Goethals' direct

involvement with the IHNC was limited, the design of the lock in the Industrial Canal bears tribute to his legacy.

In addition, the construction of the IHNC lock included several regionally and nationally significant precedents, such as the design of the lock chamber and the emergency dam system. Several of the innovative features of the lock were designed in response to unique local soil conditions that necessitated new theoretical approaches to reinforced concrete design. The features of the IHNC lock were described in detail in Chapter VIII of this report; Chapters VI and VII also reviewed the development of the relevant technologies, providing a comparative base for analysis of the Industrial Canal facility. Examination of contemporary locks, in the region and elsewhere, has suggested that the IHNC lock possesses information potential associated with outstanding construction techniques and mechanical designs of the early twentieth century. It exemplifies a distinct period in the development of mechanical, structural, and hydraulic engineering.

Maritime/Military History

The construction of the Inner Harbor Navigation Canal, and its subsequent connection to the Gulf Intracoastal Waterway (GIWW) and to the Mississippi River Gulf Outlet (MRGO), should be viewed as important components of the completion of the nation's system of inland waterways. The development of this system is significant within the history of the United States in terms of economic development and national defense. The GIWW stretches from Brownsville, Texas to Ocala, Florida. This waterway assured that inland shipping may continue in the event of war; an inland route is much easier to defend than an open water route. Chapter IV described the development of the United States inland waterway system; the context within which the IHNC was constructed was described in Chapter V. Because of its contribution to the national defense and economy, the IHNC lock appears to have significance on a national level. Locally, the IHNC lock functions together with the Harvey and Algiers locks to provide a network of access and egress between the National Inland Waterway System, the Port of New Orleans, and the Gulf of Mexico.

Criteria Considerations

As a result of the preceding analyses, it has been demonstrated that the IHNC lock may possess the quality of significance as defined by the National Register Criteria A, B, and C (36 CFR 60.4). The IHNC lock may be:

... associated with events that have made a significant contribution to the broad patterns

of our history....

(It may be)... associated with the lives of persons significant in our past....

(And, it may) embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction (36 CFR 60.4:1).

The IHNC lock does not meet Criterion D of the National Register of Historic Places (36 CFR 60.4). That is, the structure itself is not likely to yield information important to the understanding of the history of the New Orleans area. Criterion D is applied most often to archeological sites; however, certain conditions permit its application to districts, buildings, structures, or objects that contain important information. information must be inherent in the actual property, or obtainable from the actual physical examination of the property, and not available through documentary research. Thus, the property must represent the primary source of important information. As demonstrated by this report, extensive documentary information exists concerning the construction and utilization of the IHNC Information important to the history of the New Orleans area can be recovered without the physical examination or study of the structure. Therefore, the IHNC lock cannot be considered significant under 36 CFR 60.4 (d).

In order to be considered a significant representation of a theme or pattern of importance in American history, a property must meet one of the four established criteria (36 CFR 60.4). The following discussion addresses each of the three relevant criteria; each of the aforementioned historical themes also are discussed with reference to the appropriate criterion. According to the Secretary of Interior's guidelines, if a property is considered to be significant, and thus potentially eligible for inclusion on the National Register of Historic Places, then it must in some way:

characterize, illustrate, reveal, or recall specific persons, events, lifeways, patterns of development, or architectural types recognized by the public or the professional and scientific community as important in our understanding of the prehistory and history of the nation.

This section demonstrates that the IHNC lock (1) characterizes a period of growth and planning in the City of New Orleans; (2) that it illustrates a significant period in the history of the engineering sciences; (3) that it reveals an opportunity to observe the continuing operation of technologies of that period; and, (4) that it tangibly recalls certain events important to understanding and interpretation of the history of the City of New Orleans, of the State of Louisiana, and of the United States of America. These events would include:

- 1. Construction of the Panama Canal.
- Construction of the Gulf Intracoastal Waterway.
- 3. Expansion of the Port of New Orleans.

Criterion A

Significance under Criterion A (36 CFR 60.4) requires that a property either is associated with a significant single event, or with more general repeated activities which, through scholarly research, have demonstrated historical consequence. The significant contributions of this property to the broad patterns of history must be clearly demonstrated.

Themes

The IHNC lock may be viewed as a good representation of the local ambitions of the citizens of the City of New Orleans. The lock stands as a direct link to a period of economic speculation in and growth of the Port and of the city during the late nineteenth and early twentieth centuries. Therefore, the recognized themes of community planning and development, commerce, economics, industry, and politics and government are relevant under Criterion A. Each of these themes has been substantiated within the body of this text. The construction of the IHNC comprised a major part of the development of a local plan for industrial and commercial expansion, and for the subsequent economic, commercial, and industrial growth of the city. The connection of New Orleans with the Federal system of inland waterways clearly contributed to national defense and to economics.

Level of Significance

Under Criterion A, the significance of the IHNC lock must be defined in terms of the local, state, or national levels. Level of significance is tied to the historical role and subsequent impact of the IHNC lock within thematic contexts. The themes relevant

under Criterion A are: commerce, community planning and development, economics, industry, politics/government, maritime history, and the military. Table 8 provides a listing of all relevant historical themes under Criterion A. In addition, Table 8 lists the chapters which may be referenced to elucidate the relationship of the IHNC lock to these themes. As Table 8 shows, the IHNC lock is assessed as significant at the local and state levels with reference to six broad patterns of history, and at the national level with reference to two broad patterns, or themes.

Integrity

As a significant exemplar of events of historical significance, a property must possess the traits necessary to convey the historical and thematic context. In addition to having a strong association with those events, the property must possess integrity. The seven measures of integrity are: location, feeling, materials, workmanship, design, setting, association. The important measures of integrity for a property are a function of the theme and the reason why that property may be significant within that theme. Under Criterion A, the most important measures of integrity are location and association with feeling and setting also being relevent; the issues of design, materials, and workmanship are considered under Criterion C. IHNC serves its original function at the exact site of its construction. It continues to represent a functionally successful solution to the relevant issues which were part of the decision to locate the lock. Therefore, it manifests the requisite integrity for National Register eligibility.

Summary: Criterion A

The IHNC lock is significant under the requirements of Criterion A. The lock clearly is associated with events which have proven to be of historical consequence to the City of New Orleans, the State of Louisiana, and the United States at large. Locally, the construction of the lock and IHNC served as a catalyst for economic, commercial, and industrial development, the ramifications of which were felt economically on a state-wide In addition, the construction of the canal and lock is associated with a political era in New Orleans that was characterized by foresight and well founded urban planning decisions. Further, the IHNC project may be viewed as an important link in the completion of the Gulf Intracoastal Waterway and thus the National Inland Waterway system; this is of national significance. There ore, the IHNC lock is considered eligible for nomination to and inclusion on the National Register of Historic Places under criterion A (36 CFR 60.4).

TABLE 8. Historic Themes, Periods, and Levels of Significance of the IHNC Lock: Criterion A.

THEME/CONTEXT	SUBSTANTIATION	TEXT REFERENCE	PERIOD/CONTEXT
Community Planning/ Development	Construction of the IMNC represents the first major step taken to achieve long-term planning goals articulated by the citizens of New Orleans and their elected officials. It is significant that the money for the IMNC project was generated through local bond issues and not federal funds. In addition, many of the original goals of the project were met.	Chapter V & IX	1865-1923
Politics/Government	The design and execution of the IHNC project is evidence of the influence and activity of such early twentieth century appointive and elective bodies as the Dock Board, and the New Orleans City Council. The history of the planning and the construction project illustrates the contemporary local political atmosphere, and concern with improvement of facilities and thus economic development.	Chapter V	1865-1923
Commerce	The IHNC and lock were responsible for the marked increase in the transshipment of goods, wares, and agricultural produce that increased both the national and international prominence of the Port of New Orleans. Prior to the IHNC project, the economic future of the Port of New Orleans was uncertain.	 Chapter IX	1923-present
Economics	During the early years of the canal, comparatively little money was generated through user fees; this revenue was lost as a result of the 1944 lease agreement with the United States Government. However, substantial revenues have been generated from 1944 to the present through rental agreements and corporate taxation associated with businesses located within the Industrial Canal corridor. Furthermore, the IHNC is directly responsible for increasing revenues in the Port of New Orleans.	Chapter IX	19 44-pres ent
Industry	The construction of the Industrial Canal and lock provided the City of New Orleans with additional acreage which could be exploited both industrially and commercially. This was a goal of the original concept by the citizens and elected officials of New Orleans. The Industrial Canal and the Hississippi River Gulf Outlet are still optimum locations for business or industry that depend on navigation or rail traffic for shipment of products.	 Chapter IX	1914-present
Maritime Mistory	The IHNC represents the con- nection of New Orleans to the Federal system of inland waterways; the benefits of this connection can be seen in terms of both economics and national defense. Locally, the project represents the completion of the idea of connecting the Mississ- ippi River with Lake Pontchar- train; the construction of the IMNC lock made this connection possible.	 Chapters III, IV,& V	1923-præsen
Military Mistory	The need for additional ship- building facilities was recog- nised during MMI; this was an important factor in the decision to build the IHMC and lock. The connection of New Orleans to the GIMN was integral to complete the guif coast network of defensible inland shipping channels; this was accomplished locally by the completion of both the IHMC and the Harvey Canal.	 · Chapters IV & V	/ 1914-presen

is, and Levels of Significance of .on A.

TEXT REFERENCE	PERIOD/CONTEXT	LEVELS OF SIGNIFICANCE
- Chapter V & IX	1865-1923	Local and State
- Chapter v	1865-1923	Local and State
- Chapter IX	1923-present	Local and State
- Chapter IX	1944-present	Local and State
– Chapter IX	1914-present	Local and State
- Chapters III, IV,& V	1923-present	Local, State, and National
— Chapters IV & V	/ 1914-present	National 32

Criterion B

The association of Major General George W. Goethals with the IHNC lock project is the key issue for consideration under Criterion B. Thus, it is necessary to ascertain if the IHNC lock was a significant undertaking in the life a person whose activities were of historical consequence. As noted above, the technologies present at the IHNC lock are very similar, indeed, to those used at the Panama Canal; a detailed account of that project was provided in Chapter VII.

Significant properties under Criterion B normally are restricted to those that illustrate the most important achievements in the life of an important individual. Thus, the question specific to this assessment is whether the IHNC lock was a significant event in the career of George W. Goethals. Research into the construction and correspondence records kept during the construction of the lock indicate a marked lack of participation on the part of Mr. Goethals. It should be reiterated here that upon leaving the military, Major General George W. Goethals associated his name with a New York engineering firm. This firm was retained by the New Orleans Dock Board for the design and construction of the IHNC lock.

The significance of Major General Goethals in the field of engineering is undeniable and well documented; the Panama Canal remains one of the greatest construction projects of the twentieth century. Nevertheless, the critical factor for this assessment is delineation of the true nature of Goethals' association with the IHNC project. It is specified in the Secretary of Interior's guidelines that:

The length of association should be identified and may be an important factor when many properties with similar associations survive.

The importance of the specific project to the career of the significant person may not be speculative in nature. While the IHNC lock had historical impact on the science of engineering, the innovations (i.e. lock chamber design, emergency dam) cannot be attributed directly to Goethals. If the Panama Canal project set many precedents, many of these were adopted as government policy shortly thereafter. Many locks of the period bear resemblance to the Panama Canal locks.

There is no doubt that certain aspects of design at the IHNC, such as the gates, gate machines, sluices, and control panel, draw their influence from the Panama Canal. This is strong evidence of the legacy of the engineering team assembled by the Corps of Engineers and by Mr. Goethals at Panama. However, the nature of Mr. Goethals' relationship with the engineering group bearing his

name appears to have been formal, rather than functional. The IHNC lock does not appear to represent a significant achievement in the life of Major General George W. Goethals. Rather, the IHNC lock illustrates the influence of the success of a more significant project in Mr. Goethals' life. Because of this indirect association, the IHNC lock does not fulfill Criterion B (36 CFR 60.4), nor is it significant under that criterion.

Criterion C

To meet the requirements of Criterion C, a property should embody the distinctive characteristics of a type or represent the work of a recognized master. Again, to qualify as the work of a master, the project must be proven to be a significant achievement representative of that person's contribution to their particular craft. Furthermore, a property must enhance our understanding of its particular group of resources, and it must illustrate patterns or common traits of that group, its evolution, or its transition. The characteristics of a particular group of resources, navigation locks of the early twentieth century, are both specific and general in nature. Specific characteristics include form, structure, plan, and the precise ways in which materials were combined. On a general level, the property may illustrate certain ideas or theories of design and construction.

Themes

Within this criterion, the recognized historic themes which apply are engineering technology and invention. This report has presented the historic context in which the IHNC lock was constructed (Chapters VI, VII, and VIII). The extant technologies, the historic prototypes, and the similar contemporary projects of the late nineteenth and early twentieth centuries also have been described. It is now possible to assess accurately the impact or historic role played by the IHNC project within the development of the engineering sciences.

Level of Significance

The determination of the level of significance (local, state, national) that the IHNC represents is contingent upon several factors. Were there any technological precedents set as a result of the project? If so, did these have impacts which extended beyond the local level, i.e., was the entire discipline of engineering influenced? These issues were assessed through comparative analysis of the IHNC project and subsequent navigation locks constructed locally, regionally, and nationally. This was accomplished using both archival sources and a survey of similar properties. This determination involved critical analysis of

methods of construction, as well as the mechanical systems employed at the IHNC lock. Table 9 is a reference for thematic considerations that apply to Criterion C. In this table, the pertinent themes are stated and substantiated. The chapters that best illustrate these themes also are listed, as are the periods of importance and the assessed level of significance (local, state, national).

Integrity

The IHNC lock is significant at the national level as an exemplar of engineering technology and of invention. Under Criterion C, the measures of integrity that apply are design, materials, and workmanship. The level of historical integrity possessed by the IHNC lock was assessed by examination of the original plans; of the maintenance, dewatering, and accident records of the last sixty years; and, by an on-site inspection of the lock. It then was possible to understand fully how the lock was constructed originally, and how it subsequently was altered. The determination of those features that were significant played an important role in the final assessment of integrity.

Under Criterion C, the issue of integrity is extremely important, since the designation of a structure (property) as a significant exemplar of a class of resources requires accurate historical preservation of its key components. The design of the complex, the original materials, and the workmanship associated with the period of construction all should be preserved as accurately as possible. The essential question is whether the IHNC lock retains the identity, or character, for which it is important in American history. As noted above, the IHNC lock remains substantially unchanged, and clearly possesses the quality of integrity.

Summary: Criterion C

The IHNC lock represents a significant structure (property) within the history of the engineering sciences. In addition, the key features of the original design remain intact and operational. The principal features of the original design and construction techniques remain; they convey the significance of the property. The historic relationships of the components of the original design have been preserved, as have their functions.

The features which render the IHNC lock significant are the design of the lock chamber; the first American use of the Schildhauer electric gate machines; the emergency dam design; and, the first use of reverse head gates. In addition, the IHNC lock is both the earliest American example and an exemplar of the Panama Canal "type" navigation lock, the impacts of which should be clear

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TABLE 9. Historic Themes, Periods, and Levels of Significance of the IHNC Lock: Criterion C.

THEME/CONTEXT

SUBSTANTIATION

Engineering/ Technology

The construction of the IHNC lock applied influential construction methologies and mechanical systems. These included the first use of many Panama canal "type" devices in the United States (gates, gate machines, sluice machinery). In addition, the IHNC lock remains operational and possess intgrity of design, workmanship, and materials.

Invention

The design of the lock chamber at IHNC represents a significant advancement in the evolution of reinforced concrete theory. The chamber is designed much like the hull of a ship; this was the first such structure in the world. In addition, the design of the emergency dam gantry crane and hooking mechanism was the first of its kind. And, the reverse head miter gates constituted the first application of its kind, illustrating both the adaptation of technology and unique design in a wetland environment. Both the chamber design and the emergency dam represent significant projects in the history of engineering.

: of

TEXT REFERENCE	PERIOD/CONTEXT	LEVELS OF SIGNIFICANCE
Chapters VI, VII, & VIII	1918-1940	National
- Chapters VI, VII, & VIII	1918-1940	National

at this point.

The design of the lock chamber was necessitated by the unstable local soil conditions. This required the construction of a monolithic cross-section which produced a nearly uniform pile loading situation. The nature of the clays beneath the lock ignored, differential settlement would have occurred. This was a relatively new building medium in 1918. The current condition of the lock chamber stands as testimony to the success of the used for the construction of both the Harvey and Algiers locks, and it represents a successful solution to the problem of placing huge has developed cracks in some locations (causing seepage), the lock will continue to meet its structural requirements for another

The gate operating machines at the IHNC are of the Schildhauer, or Panama Canal type. This design was praised during the period as the most modern and streamlined approach to the task of gate operation. The IHNC project represents the first time such mechanisms were used in the United States; these machines still function today. Additionally, the gate machines at the IHNC lock represent an improvement upon the original Panama Canal design; at IHNC, the size of the machines has been reduced, that these machines still work as well as when they originally were constructed speaks for itself.

The emergency dam system at the IHNC lock also was a "first of its kind" design, and it was highly regarded during the period of construction. The crane and stop log (girder) system at IHNC redefined the approach to emergency systems for navigation locks. Both the Harvey and Algiers locks employ systems which draw direct influence from the design of the IHNC dam. The pick-up and release also is the most significant feature of the emergency dam; it questioned the reliability of the gantry crane and hoisting system, the emergency dam has been used successfully during Faith accident in 1972. The emergency dam at the IHNC should be at LHNC original.

Finally, the use of reverse head gates at both ends of the IHNC lock also set a precedent; this, too, was dictated by the local

natural setting. As described in Chapter VIII, there are periods when Lake Pontchartrain is higher than the Mississippi River; this occurs during storm surges associated with hurricanes. In response to this situation, two additional sets of gates which bevel toward the lake were constructed. This was the first navigation lock in the world constructed in such a fashion, and it therefore possesses national significance.

Generally, the IHNC lock is a significant structure within the context of historic engineering achievements. The lock may be viewed as an outstanding representation of influential construction methodologies and mechanical assemblages. In addition, the IHNC lock possesses the requisite integrity of design, workmanship, and materials to convey this historic significance. On a regional level, the IHNC facility is the oldest operating navigation lock in the area; this, combined with the design precedents associated with the construction, render the IHNC lock locally significant.

The IHNC lock represents a chance to observe an operating example of the Panama Canal technologies in the United States. In addition, the lock serves to illustrate certain theoretical successes in the development of reinforced concrete systems, mechanical designs, and first use features such as the reverse head gates. The IHNC lock is a significant exemplar of engineering technology and invention as defined by Criterion C of the National Register Criteria (36 CFR 60.4).

Conclusions

The IHNC lock meets both Criteria A and C (36 CFR 60.4). That is, it has significant associations with events that have contributed to the broad patterns of American history; and, it is an exemplar of a type of resource, navigation locks, and it embodies the distinctive characteristics of its type and period of construction. It is significant at the local, state and national levels. It also manifests integrity of design, association, feeling, setting, materials, workmanship, and location. As a result, the IHNC lock is considered eligible for nomination to and inclusion on the National Register of Historic Places.

The Historic District Question

Before addressing mitigation alternatives, it is necessary to discuss briefly the potential for an historic district. There is a need for further research into a discontiguous district centered around the themes of navigation and commerce. The IHNC and Harvey locks represent two historic locks that possess the

requisite age for National Register consideration. The original Harvey lock was completed in 1909; the existing lock was completed in 1934. The Inner Harbor Navigation Canal lock of course was completed in 1921. Both the IHNC and the Harvey Canals are integral in the network of man-made waterways which serve the function of connecting the City of New Orleans with the Gulf Intracoastal Waterway, the Mississippi River Gulf Outlet, and the Gulf of Mexico.

Additionally, the 1934 Harvey lock exhibits direct influence from the design of the IHNC lock. This serves to illustrate the impact of the IHNC lock on the design of subsequent structures. It also is interesting to observe the subtle differences between the two complexes, in terms of the scale of the mechanisms and the number of safety or limiting devices. The Harvey lock represents a further evolutionary step of the Panama Canal/IHNC navigation lock type.

In the future, an historic navigation district also may contain the Algiers lock, located roughly six miles downriver from the Vieux Carre. It was constructed in 1953. Both the Harvey and Algiers Canals connect the City of New Orleans with Bayou Barataria and the GIWW to the south. The lock at Algiers represents a further step in the evolution of navigation locks; the three locks in the New Orleans area provide a fascinating technological chronology.

Although it is not within the scope of work to develop the themes and assess the integrity of a potential navigation district, it was impossible to avoid mention of the existence of such a district based on the present level of research. In any event, there appears to be a strong case for the consideration of "The New Orleans Historic Navigation District."

The IHNC lock is adjacent to the Holy Cross Historic District. This historic district, lying between North Rampart Street and the Mississippi River, extends downriver from the southeast corner of the lock complex to Delery Street. The Holy Cross Historic District is significant due to its unique representation of the residential expansion of the City of New Orleans between 1880 and The district 1936, as expressed by extant architectural remains. contains one of the highest concentrations of shotgun houses in the Gulf Coast region; most display recognizable architectural elements necessary to define styles within the building type. considered significant under themes engineering/invention, economic/commercial/industrial development of the region, and maritime and military history. Thus, the lock does not possess the characteristics necessary to associate it with the Holy Cross Historic District. Therefore, the IHNC lock complex cannot be considered a component of the adjacent historic property.

Mitigation Alternatives

The assessment of the IHNC lock as a significant historic navigation lock requires the determination of both the nature and the effect of potential impacts to that property. Because the New Orleans District, Corps of Engineers, has not completed its plans to identify the location and scope of a proposed replacement lock, this report assumes the worst case scenario. That is, the direct demolition of the IHNC lock. This assumption is an heuristic device to assure that this significant resource will receive maximum substantive regulatory scrutiny.

A direct physical impact to the present IHNC lock would represent the destruction of a significant accomplishment associated with the development both of the science of engineering and of the economy of the City of New Orleans. The lock offers a rare opportunity to observe a fully operational example of early twentieth century engineering technologies. There are no other such locks of the period in the region.

If at all possible, all work should be designed so that it avoids the IHNC lock entirely. The stability of the lock is contingent upon the integrity of the backfill surrounding it; if dirt is removed from the sides, hydrostatic pressure from the water in the chamber may force the walls outward. The structural integrity of the lock chamber remains intact after more than 65 years of continuous use; this should not be jeopardized. Thus, the IHNC lock site should be avoided by construction, and the resource should be preserved in place.

If avoidance is impossible, a thorough HAERS documentation should be contracted by the New Orleans District, Corps of Engineers. This should include an intensive graphic and photogrammetric recordation of the historic lock, as well as cinematic documentation of the operation of the original machinery. The results of this recordation effort should be curated in perpetuity at an appropriate Federal facility. The significance of this resource within the field of engineering is paramount to future recognition and understanding of an important aspect of American history. Thus, mitigation measures also should comprise a plan to disseminate, as well as to preserve, a complete record of the construction and operation of this facility.

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APPENDIX I: SCOPE OF SERVICES

Scope of Services Evaluation of the National Register Eligibility of the Inner Harbor Navigation Canal Lock in Orleans Parish, Louisiana.

- 1. <u>Introduction</u>. The purpose of this study is to determine the National Register eligibility of the Inner Harbor Navigation Canal (IHNC) Lock located in Orleans Parish, Louisiana. The Lock is operated and owned by the U.S. Army Corps of Engineers, New Orleans District.
- 2. <u>Project Background</u>. Interest in New Orleans in construction of an inner harbor dates back at least to 1845 but modern interest in the project dates to 1902. Work on the Lock began in 1918 and it was dedicated in 1921. The State of Louisiana and the City of New Orleans built the IHNC canal.

The IHNC Lock was constructed by a company headed by Colonel George Goethals, builder of the Panama Canal. The Lock was designed to be 1,020 feet long, 150 feet wide, and 68 feet deep. Constructed of concrete and steel, it weighed 225 tons. The usable dimensions of the Lock were 600 feet by 75 feet. The Lock is a complex work of engineering design and construction in a hostile environment. The soil was soft with quicksand and marsh gas. Coffer dams were used to wall off the quicksand. When the site was dewatered before driving the foundation piles and laying the concrete, pressure on the quicksand caused slides and problems with the bottom of the site. This pressure was relieved by sinking 186 artesian wells which solved the pressure problem. The Lock foundation rests on 24,000 pilings.

The IHNC Lock is considered potentially eligible for inclusion in the National Register of Historic Places. Based on available information, the lock may be eligible under several of the criteria for evaluation in Title 36 CFR Part 60. The Industrial Canal and Lock, completed in 1923, was one of the more significant public works in the history of New Orleans and played a role in the rebirth of waterborne commerce on the Mississippi River (criteria 60.4a). The lock was built by a company headed by Colonel George Goethals, a significant individual in American history (criteria 60.4b). Colonel Goethals was the Chief Engineer for construction of the Panama Canal and the first Governor of the Panama Canal Zone prior to his involvement in the construction of the IHNC Lock. Finally, the lock may be eligible because of its significance in engineering history. The solution of severe foundation problems, the design of the structure to withstand reverse head pressure, and the possibility of original and unique design features may be significant elements (criteria 60.4c)

- 4. Study Requirements. The study will consist of five phases: development of a historical research strategy, archival research and oral history, on-site inspection, development of historic context, and synthesis and report preparation. Development of the historical research strategy is the first phase of the work. The archival research and oral history phase, on-site inspection, and development of the historic context can be worked on simultaneously, followed by synthesis and report preparation. The IHNC will be evaluated not in isolation but rather within its historic context. The Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation, especially those for Preservation Planning and Evaluation and the NPS draft guidelines entitled "How to Apply the National Register Criteria for Evaluation" apply to this effort.
- a. Phase 1: Development of Historical Research Strategy. The historical research conducted during this study will be guided by a historical research strategy. The purpose of the historical research strategy is to define the scope of the research, state the goals of the research, define the methodology, and provide for evaluation of the results. This task shall be completed by the contractor in the form of a letter within 1 week after award of the work order. Upon completion of this task, the Principal Investigator will meet with the Technical Representative to review the historical research strategy.
- b. Phase 2: Archival Research and Oral History. Archival sources available for this study include, but are not limited to, records of the Board of Commissioners of the Port of New Orleans and the U.S. Army Corps of Engineers including 5 volumes of engineering drawings and photographs stored at the Lock.. Oral history interviews will be conducted as necessary with persons knowledgeable about the history of the Lock. These interviews will be limited to site specific information about the Lock and other structures on the property and need not be transcribed. To assist in the development of the historic context of the Lock, historians familiar with the history of navigation and engineering structures on the Lower Mississippi River should be consulted. Walter Carlson, a specialist in planning, wrote a history of the IHNC Lock while working for the Board of Commissioners of the Port of New Orleans, and he is very familiar with the records stored there. This task will be completed by the contractor within 10 weeks after award of the work order.
- b. Phase 3: On-Site Inspection and Recordation and Analysis. Comprehensive documentation of the Lock and associated structures on the property consisting of photographs, existing drawings or others as needed, and written documentation will be developed to assist in evaluating the property. This task will be completed by the contractor within 10 weeks after award of the work order.

- C. Phase 4: Development of Historic Context. A historic context for the Lock will be developed following the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation, especially those for Preservation Planning and Evaluation and the NPS draft guidelines entitled "How to Apply the National Register Criteria for Evaluation." Data will be gathered and analyzed using currently accepted historical methods. The Lock should be placed in the historic context of navigation on the Lower Mississippi River and the Gulf Intracoastal Waterway including other locks in the area (Plaquemine Lock, Harvey Lock and others). This task will be completed by the contractor within 18 weeks after award of the work order.
- d. Phase 5: Synthesis and Report Preparation. The information gathered during the study will be used to evaluate the significance of the Lock in terms of National Register criteria. The gates were designed to be bouyant with hatches and sump pumps and should be carefully examined to determine their significance. Other features of the lock and associated structures including the original lock master's house may be significant. This evaluation of the lock must be very specific to guide selection of mitigation alternatives. The contractor will make recommendations supported by the written report concerning the National Register eligibility of the Lock. If the contractor recommends the Lock as eligible for inclusion in the National Register, all management and mitigation alternatives will be assessed in the draft report. Upon completion of these analyses, a report of the study results will be prepared.

5. Reports

- a. . Two copies of the historical research strategy will be submitted to the COR within 1 week after work item award for review and approval.
- b. <u>Draft and Final Reports</u> (<u>Phases 1, 2, 3, &4</u>). Six copies of the draft report integrating all phases of this investigation will be submitted to the COR for review and comment within 22 weeks after work item award. Along with the draft reports, the Contractor shall submit either three copies of support documentation for determination of eligibility in the National Register or National Register forms (National Register of Historic Places Inventory-Nomination Form), whichever is required by the COR. This documentation will follow the format and contain all the data required by the Guidelines for Level of Documentation appended to Title 36 CFR Part 63. The Contractor shall also provide recommendations for management and mitigation of the site if he recommends it as eligible. The COR will provide all review comments to the Contractor within 8 weeks after receipt of the draft reports (30 weeks after

work item award). Upon receipt of the review comments on the draft report, the Contractor shall incorporate or resolve all comments and submit one preliminary copy of the final report to the COR within 2 weeks (32 weeks after work item award). Upon approval of the report, the Contractor will submit 30 copies and one reproducible master copy of the report to the COR within 2 weeks after approval of the report.

The written report shall follow the format set forth in MIL-STD-847A with the following exceptions: (1) separate, soft, durable, wrap-around covers will be used instead of self covers; (2) page size shall be 8-1/2 x 11 inches with a 1-1/2-inch binding margin and 1-inch margins; (3) the reference format of American Antiquity will be used. Spelling shall be in accordance with the U.S. Government Printing Office Style Manual dated January 1973.

- 6. References. At a minimum the following sources will be consulted by the Contractor:
 - o the National Park Service's draft standards entitled "How to Apply the National Register Criteria for Evaluation," dated June 1, 1982;
 - o the Secretary of the Interior's Standards and Guidelines for Archeology and Historici Preservation as published in the <u>Federal Register</u> on September 29, 1983;
 - o Louisiana's Comprehensive Archaeological Plan dated October 1, 1983:
 - o The Advisory Council on Historic Preservation's regulation 36 CFR Part 800 entitled, "Protection of Historic and Cultural Properties," and Section 106, Update 3, entitled, "Manual of Mitigation Measures (MOMM), dated October 12, 1982.

